CRANFIELD UNIVERSITY

ALEXANDRE BRADLEY

A COMPARISON OF WHOLE LIFE CYCLE COSTS OF ROBOTIC, SEMI-AUTOMATED, AND MANUAL BUILD AIRPORT BAGGAGE HANDLING SYSTEMS

DEPARTMENT OF AIR TRANSPORT, SCHOOL OF ENGNEERING
MPhil/PhD

PhD THESIS
Academic year: 2012-13

Supervisors: Dr Romano Pagliari / Mr Richard Moxon
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This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

I. ABSTRACT

This thesis proposes that a baggage handling system (BHS) environment can be defined and coupled to a whole life cycle cost (WLCC NPV) model. The results from specific experiments using the model can be used as the basis by which to commercially compare BHS flight build[1] types of any capacity, and BHS geographical location.

The model examined the three flight build types: (i) Fully automatic build[2]; (ii) Semi-automatic build[3], and; (iii) Manual build[4].

The model has the ability to calculate a bag flow busy hour rate, and to replicate the baggage flow characteristics observed within real BHS operations. Whole life cycle costs (WLCC NPV) results are produced, and these form the basis by which the comparison of BHS types is made. An overall WLCC NPV scatter diagram was produced, which is a summation of each of the test sensitivities. The assumptions[5] and limitations of the analysis are provided. It is proposed that the results, conclusions and recommendations shall be of value to airports, airlines, and design consultants.

Key terms: Baggage handling systems comparison, robotic flight build, semi-automated flight build, manual flight build, airport BHS capital and operating costs.

[1] "Built or build" denotes process of (i) removal of a bag(s) from baggage system chute or lateral (ii) scanning of bag to verify authorised to load bag status (iii) loading of bag into a ULD or baggage cart.
[2] Fully automatic build: A mechanised robotic device physically loads the baggage into the containers or baggage carts essentially independent of baggage handler person.
[3] Semi-automatic build: A mechanised device, operated by a baggage handler non-directly loads the baggage into the containers or baggage carts.
[4] Manual build: Also known as conventional build, where a baggage handler picks up baggage from the baggage system and inserts them manually into containers or baggage carts.
[5] Assumptions: To determine the size, and functionality of a baggage handling system using a WLCC model approach, certain variable assumptions must be made. The key assumptions in this regard are declared.

II. DEDICATION

“This thesis is especially dedicated to my wife, to my children, my mum, and to my late father”

III. ACKNOWLEDGMENTS

Cranfield Team

First and foremost I would like to thank my supervisors at Cranfield University Dr Romano Pagliari, and co-supervisor Mr Richard Moxon. Dr Pagliari, with support from Mr Moxon outlined the path I needed to take to ensure my research skills, and my report writing skills were fit for purpose. When I was not sure which path to take they provided a foundation of sound logic, and reasoning which provided me with the self confidence that I required during some difficult periods. For that alone I am truly grateful. They also showed a continued enthusiasm for my chosen researched subject matter. I would also like to thank the back office team at Cranfield, namely Tracey Clarke, and Heather Hill for the high quality clerical support I received. Finally I would also like to thank Dr Simon Templar from Cranfield School of Management for his assistance with financial appraisal tools.

Aviation Industry

This PhD required support from industry experts. The following persons/organisation assisted me with either the provision of data, industry insight, and enthusiasm: Alan Cowper (Heathrow Airport), David Stewart (International Air Transport Association), David Unwin (Davis Langdon), Giles Price (Heathrow Airport), Hilary Dolye (American Airlines), John Briggs (Independent Consultant), Mark Tayler (Air Canada), Mike Wood (Heathrow Airport), Paul Bellamy (Independent Consultant), Stewart Shortland (London Airport Operators Committee), and finally Tony Batchelor (Independent Consultant).

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VIII. LIST OF ABBREVIATIONS

Abbreviation	Description
ACI	Airport Council International
ADRM	Airport Development Reference Manual published by IATA
AMS	ICAO airport code Amsterdam Airport
AOC	Airline Operators Committee (London Airports)
ATL	Authorised to load baggage
BAA	Company formerly known as British Airports Authority
BHS	Baggage handling system
BSM	Baggage Source Message
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CAD	Computer Aided Design
CUTE	Common User Terminal Equipment
Dbase	Database
DCV	Directly Controlled Vehicle
EBITDA	Earnings before interest, taxes, depreciation and amortization
EM	Empirical model
EU	The European Union
FAT	Financial Appraisal Technique
HBS	Hold Baggage Screening
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
IRR	Internal Rate of Return

VIII. LIST OF ABBREVIATIONS

Abbreviation	Description
ISO	International Standards Organisation
IT	Information Technology
JIT	Just in time
LCOMC	Life Cycle Operational and Maintenance Costs
LHR	ICAO airport code London Heathrow Airport
NPV	Net Present Value
OPEX	Operating Expenditure
QTY	Quantity
RTT	Product name RTT Longreach semi-automated bag loader (supplier Telair International)
SITA	Société Internationale de Télécommunications Aéronautiques
SQ	ICAO Airline Code: Singapore Airlines
STD	Standard time of departure of flight
STN	ICAO airport code Stansted Airport (BAA)
ULD	Unit load device
UTL	Unauthorised to load
VS	ICAO Airline Code: Virgin Airways
WACC	Weighted average cost of capital
WLCC NPV	Whole life cycle cost - net present value

1. INTRODUCTION

1.1 Background

Following the trial installations of fully automatic robotic baggage loading technology at Amsterdam airport, and semi-automated baggage loading technology used at Heathrow Airport, the commercial question has arisen as to which of these new technologies, when compared to manual baggage loading, produces the most cost effective BHS solution, when used within international or domestic passenger airports.

Departing hold[6] baggage handling systems are used in passenger airports. Passenger hold baggage is inserted into a BHS, where it undergoes a series of baggage processes. These processes ensure that the baggage gets on the same departing flight as the corresponding passenger, and that all baggage has been X-ray security screened, and deemed safe to be loaded on to the outbound aircraft.

Manual conventional build BHS processes use staff to load baggage into the baggage holding device owned by that airline. These devices are known as: (i) Unit Load Device (ULD[7]) or (ii) Baggage carts[8]. Conventional manual BHS specifications are documented by IATA (2004). With independent cost advisor support, these BHS can be sized, and their capital and operating costs can be calculated for any required system capacity.

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[6] Hold: position in the belly of commercial aircraft used to store passenger hold baggage.

[7] Unit Load Device: also known as ULD, an aluminium container used to store passengers hold baggage whilst within the airport baggage hall, or on the airport apron, or within the hold of aircraft able to accommodate such devices, as defined by the International Civil Aviation Organization (ICAO) Annex 1.

[8] Baggage Carts: wheeled steel containers used to store passenger hold baggage whilst within the airport baggage hall or on the airport apron. These units are not loaded onto the aircraft and reside at the airport at all times.

Figure 1 details six typical possible BHS hall locations relative to the main passenger areas, and the aircraft pier infrastructure. There can be many airport / geographic specific reasons for selecting one BHS option location over another. These reasons can include:

(i) Land or infrastructure availability;

(ii) Capital and operating cost considerations;

(iii) Security characteristics.

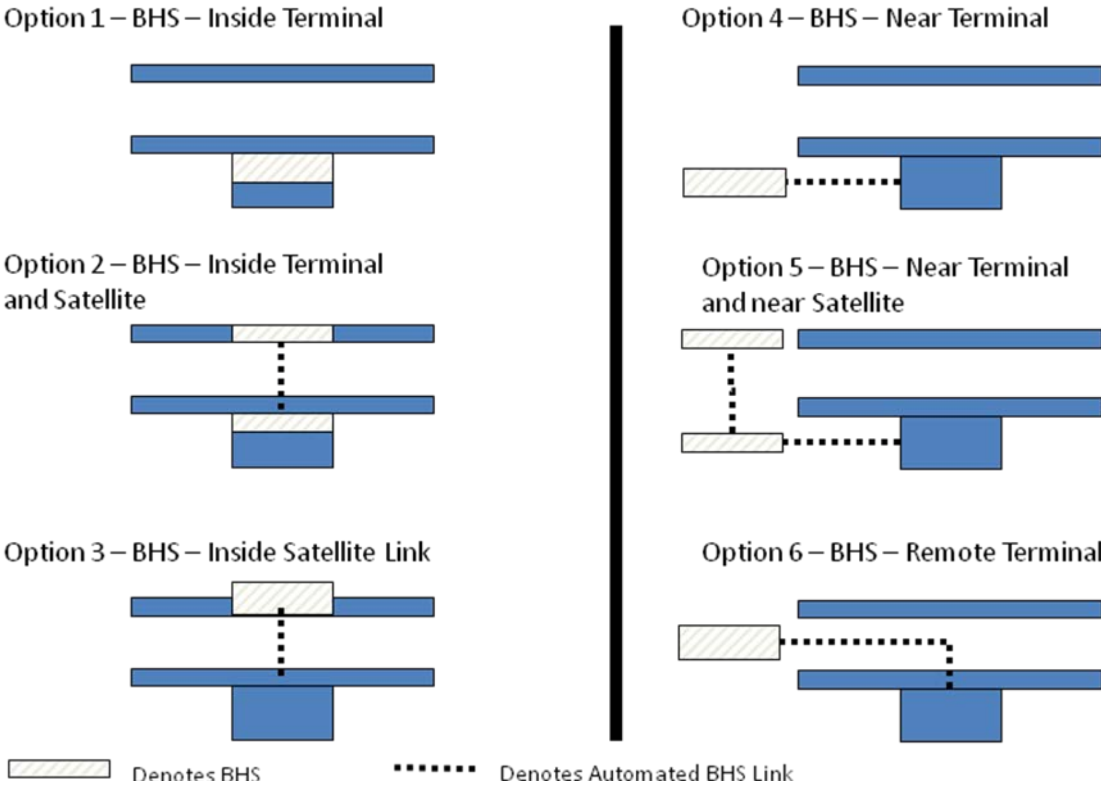
BHS are normally located within the terminal building complex as per option 1 in Figure 1. They can also be located in separate baggage buildings, attached by umbilical baggage system technology that connects the terminal building with a satellite baggage processing building as per options 2, 3, 5, and 6 as shown within Figure 1.

Baggage handling systems are categorized by IATA (2004) according to the peak bags/hour flow rate that they process. Category[9] A baggage systems are the smallest and simplest, and Category C are the largest and most complex. Each category of system has a set of IATA recommended baggage system processes, and technologies to consider adopting.

[9] IATA Category A denotes bag flow rate of up to ≤ 999bags/hour Peak
IATA Category B denotes bag flow rate of ≥1000bags/hour ≤ 4999 bags/hour Peak
IATA Category C denotes bag flow rate of ≥5000 bags/hour

Figure 1: Possible BHS locations

Source: Bradley (2010) Independent Airport Planning Manual



1.2 Statement of the problem

Advances in computer processing, and sensor technology, including the use of robotic systems, now present the opportunity for airports to use semi-automated or fully automated baggage loading equipment, to build the hold baggage of departing flights. The semi-automatic and fully automatic baggage flight build technologies could theoretically be used in any airport of any size. There are no published recommended practices for the use of semi or fully automatic flight built loading technologies. A gap in knowledge exists determining when it is operationally, and commercially most effective to select semi or fully automated baggage loading technology in favor of conventional manual baggage system flight build equipment.

Completion of the PhD aim and objectives provides an analysis tool, model, analyzed results and conclusions that can be referenced by both the User Group[10] and the Specialist Group[11]; the results allow these groups to make informed impartial decisions regarding the use of the appropriate BHS build technology.

The model shall be used to determine if it is appropriate to deploy this equipment for a specific airport capacity taking into account various sensitivities that are outlined in Section 5 of this thesis.

1.3 Aim and objectives

The aim of the research is to determine, for any given set of baggage demand flow rates, the point at which it is more cost effective, from a capital cost, and operating cost perspective, to select fully automated or semi-automated baggage build technologies in favour of conventional baggage build technologies when processing departing hold baggage.

1.3.1 Objectives

To meet the above research aim, the following objectives were identified. All objectives were started in parallel, with the exception of Objective 4. Objective 4, the completion of the model could only be completed when objectives 1, 2 and 3 were first completed. The objectives were:

(i) To determine the point at which it is operationally most effective to use semi, and fully automatic baggage loading technologies;

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[10] User Group: airport operators, airport regulators, airline handlers and airline organisations.

[11] Specialist Group: specialist baggage handling system consultants, baggage handling system manufacturers.

(ii) To determine the semi and fully automated and conventional manual baggage handling processes and technologies, and the performance capabilities of said technology for the use of loading of baggage into unit load devices;

(iii) To estimate the capital and operating costs for semi and fully automated and conventional airport baggage handling systems;

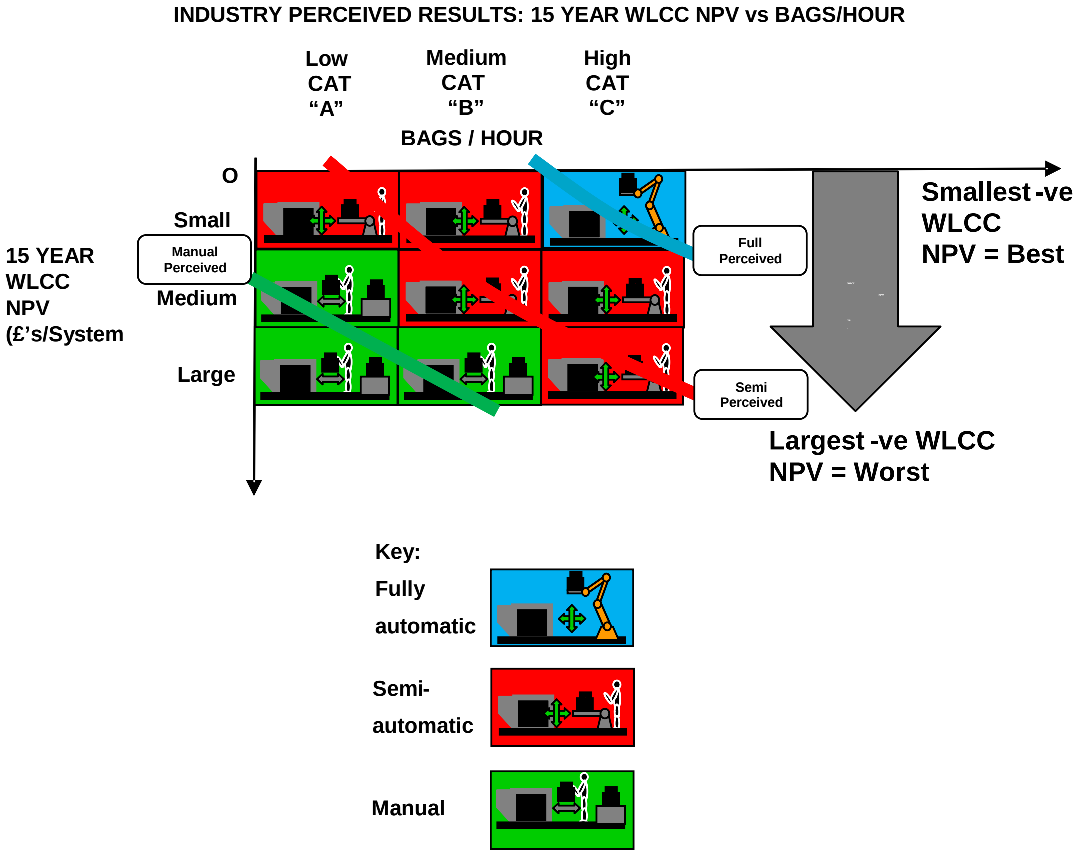
(iv) To develop a model that shall construct three BHSs, one for each flight build type. The model shall define the size of the building envelop that would enclose each of the BHS flight build types. The model shall calculate the WLCC NPV values for each BHS solution constructed. The model shall be used to construct IATA Category A, B and C BHS solutions, and have the ability to test the commercial and operational boundary conditions that could exist across world airports.

1.3.2 Pre-investigation industry perceived view

Prior to the study, the assumption was that semi and fully automatic build technologies might only be commercially and operationally viable for the larger Category B and C airports, IATA (2004).

Figure 2 graphically represents the pre-investigation industry view; the coloured blocks shown were not based on any calculations, and can now be compared with the final study results seen in Chapter 5, determined from the completion of the experiments also detailed in Chapter 5, and the test sensitivities defined in Table 7 calculated using the model.

Figure 2: Pre-investigation industry view



1.4 Method of study

This section outlines how the study was carried out, and what route was taken to come to meaningful results and conclusions.

Following completion of the literature review it was necessary to construct a model that would be subjected to a series of planned experiments. The results of these experiments would be analysed and conclusions drawn and documented to answer the PhD aim. Such a model would need to reference best practice baggage system processes, IATA (2004). In the situation of fully, and semi-automated build processes, best practice guidance has not previously been documented. It was therefore necessary to look to the baggage handling industry for state of the art baggage system solutions, Bellamy (2009), and airport installation experience of recent fully automated robotic build technologies as used at Amsterdam airport, Samola Betty, (2008).

The model has a series of inputs that effectively define the throughput or "demand forecast" of the baggage systems that are to be compared.

To construct meaningful processes, and proportions of technologies the model references equipment throughput rates, and constants which have been determined through analysis of real equipment and operational data obtained from BHS project layouts from Amsterdam airport, Gatwick airport, Glasgow airport, Heathrow airport, Hong Kong airport, Panama airport, and Prague airport.

The model constructs baggage system solutions for the three types of systems being assessed (manual build/semi-automated build/fully automated build). This in turn determines the size of a baggage handling building that will house these pieces of equipment. Capital and operating cost data was obtained from independent cost consultants, and airlines, Briggs, (2009), Dolye, (2010), Cowper, (2010), IATA (2004), Shortland, (2010), Stewart (2010), Taylor, (2010), Unwin, (2009).

The resultant capital cost and operating cost of each of the three types of baggage handling systems are then managed into a whole life cycle cost model, Nopper, and Hompel (2010), for the design life (declared to be 15[12] years) of the baggage handling equipment. This data is then stored in a results database. The results of the model were validated[13] against real airport system data.

[12] BHS suppliers warrant the performance of BHSs over a 15 year declared life period.

[13] Validated: Process by which a real airport baggage handling system size which has been designed for a specific demand has been compared to that of the output data obtained from the WLCC model. Validated model, means that the WLCC model compares favourably with real airport systems data.

Experiments were devised to test reasonable system design boundary conditions that could be expected. The boundary conditions would look at capital costs, operating costs, inflation and baggage handler staff loading rate sensitivities. Furthermore the experiments would be carried out for throughput rate demands that are experienced in IATA Category A, B and C baggage handling systems.

1.5 The research case

This research shall ultimately provide best practice guidance for the User Group, and the Specialist Group, by impartially researching, and assessing data pertaining to the use of the new semi and fully automated build technologies.

The capital cost, and operating cost of automated or conventional BHSs is not defined in any previous literature. Available advice that does exist is technically and commercially biased and cannot be relied upon. The User Group needs independent guidance on when it is operationally appropriate, and cost effective to adopt semi and fully automatic baggage systems, in place of conventional baggage systems. A gap in knowledge exists and only small fragments of information are available in this regard, none of which would satisfy the aim of this proposed research.

1.6 Research material requirements

To meet the objectives detailed herein, it has been necessary to undertake a continuous literature review to research the immediate and surrounding subject matter. This has determined what knowledge already exists, and what information has been helpful to answer the aim of this research. Chapter 2.0 of this thesis details the "fields of interest"[14] that were researched in this regard.

1.7 Background: Push and Pull BHSs

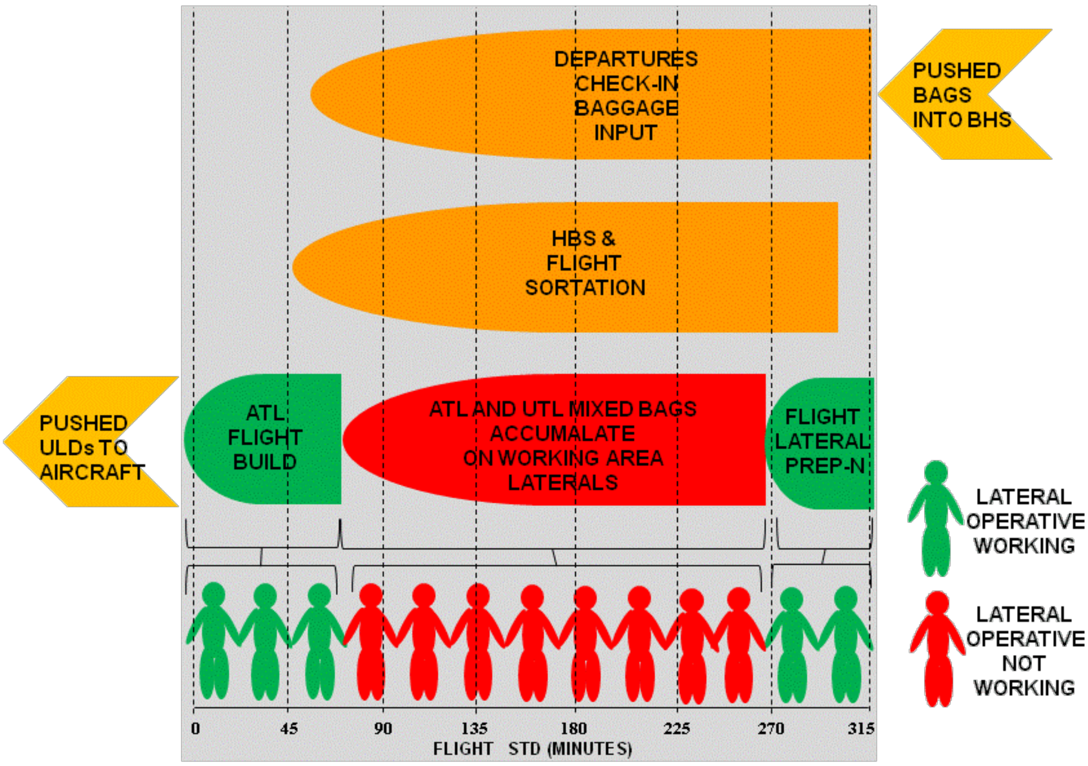
Airlines have expanded over the decades using baggage systems which have been run by often heavily unionized workforces. Older less advanced technology baggage systems often require numerous staff to operate them. Some automatic loading systems such as robotic build can result in less staff being required. The model can only assume that it is possible to make the necessary industrial relations transitions.

Figure 3 details the inefficient use of flight lateral[15] space currently witnessed with all existing baggage handling systems. The green activity is work done such as Check-in, Hold Baggage Screening, and manual BHS bag build activity. The red activity is periods where work is not being done on the baggage, and often the baggage is static in the system. This is not an efficient use of baggage handling technology / resources since there are prolonged periods of inactivity. This "pushed bag" process is also known as a conventional manual loading process where flight build is inefficient. Bags get checked in, screened and sorted to the flight output and stored for long periods on the flight lateral pending manual loading into ULD's. This occupies a significant amount of valuable ground space and requires last minute rushed bag staffed activity to ensure that all the bags are loaded onto the flight on time.

[14] The "fields of interest" researched are: (i) Financial appraisal methods; (ii) Baggage processing technology; (iii) Baggage operational processes; (iv) Capital and operating costs of BHSs, and (v) Benchmarking BHS equipment and staff benchmarking costs.

[15] Flight lateral – device used to store departing baggage by flight / class segregation.

Figure 3: Conventional "push" baggage system (departures & transfer function), steps 1D to 5D & steps 1T to 2T.



Automatic loading technologies could be used in any airport of any size. The model will be used to determine if it is financially appropriate to deploy this equipment for a specific capacity. Robotic technology is expensive to install and technically complex and bulky. The equipment is well proven though and robust following extensive development and live baggage trials conducted in Amsterdam Airport from 2002.

There is semi-automatic baggage loading equipment such as the Teleair RTT (brand name) units. The main difference with these units compared to the robotic (fully automatic) baggage loading solution is that these units each require an operator to manipulate the bag loading head unit.

Figure 4 defines the break points when it is appropriate to build baggage automatically.

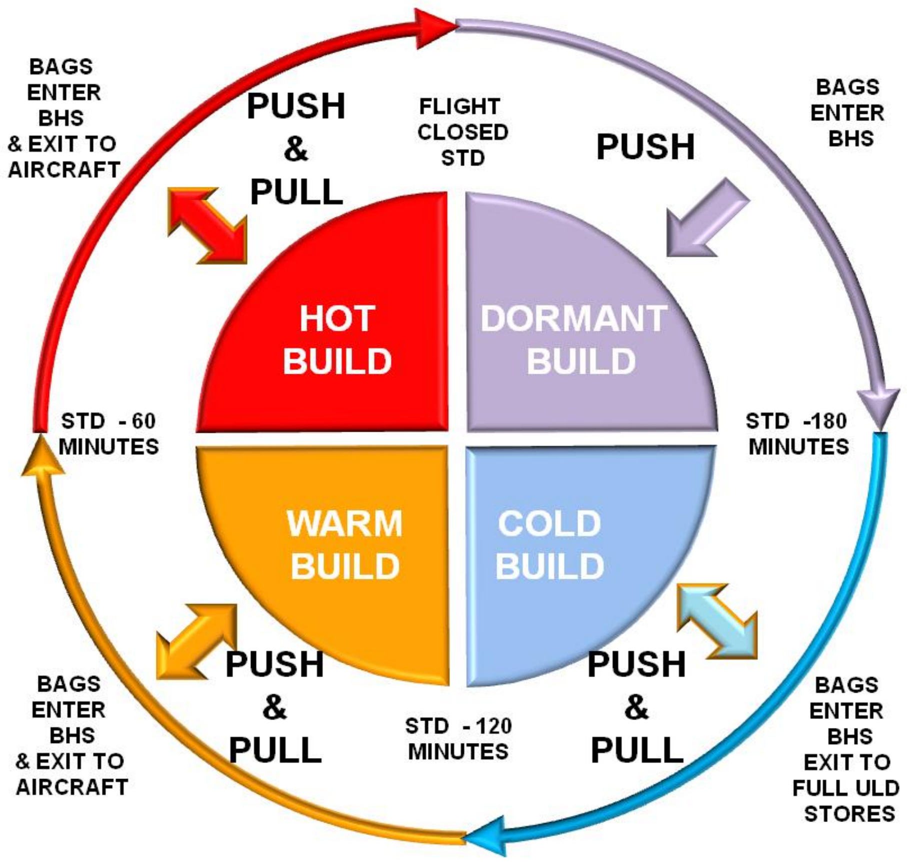
Hot Build = Too late for automated baggage build due to build cycle time

Warm Build = Time critical automated baggage builds

Cold Build = Non time critical automated baggage builds

Dormant Build= Too early or insufficient data or resources to build baggage automatically

Figure 4: Real time push/pull automated bag build philosophy



In the above automatic build process the baggage system pulls the bags from the bag store in batches and matches them and builds them automatically into the available empty ULDs. This is a very efficient use of space and resources.

1.8 Introduction: baggage processes

The original push operating model concept of processing departures baggage Figure 3 is defined by the steps that follows:-

Step 1D[16] Hold baggage is checked in. This can be either a self-service process or a staff assisted process. Baggage is weighed and labelled and security questions are answered.

Step 2D Hold baggage which have a poor quality label or baggage identification problems are dealt with by either the BHS controls, or by an operator manually, this ensures that flight and passenger identifications match appropriately.

Step 3D Hold baggage is transferred to the hold baggage screening process where high security risk baggage is separated from low / no risk baggage. Low/no risk baggage is permitted to proceed to the flight sortation process, or early baggage storage process.

Step 4D Some BHSs permit early baggage to be stored until such time as it can be processed by the flight sortation system. This baggage is then released when the flight opens.

Step 5D With a manual category A baggage sortation system, IATA (2004) where hold baggage has cleared screening, and where the bag has the appropriate label details, the baggage is permitted to progress to flight sortation. Flight sortation usually

[16] Step #D denotes step number # of the Departures baggage process

occurs when the flight is open. This is usually 120 minutes before standard time of flight departure (STD-120). At this point all the baggage is directed onto racetrack[17] unit(s). Airline handlers then, manually sort the baggage by reading the label. The process is manually intensive, and prone to human error due to label / flight identification reading errors. The final process is to manually unload baggage from the BHS, and then positively confirm the security status of each piece of luggage. This often involves the airline handler lifting the bag, and twisting their body to load baggage into the ULDs. It is this final process where the lifting and twisting occurs that creates the adverse health and safety problems, and where low bag loading/flight build rates exist.

Step 5.1D With Category B and C , IATA (2004) BHSs, where hold baggage has cleared screening and where the bag has the appropriate label details, the baggage is permitted to progress to flight sortation. Flight sortation usually occurs when the flight is open. This too is usually at STD-120. Often at this point the BHS has chute(s)[18], or flight lateral(s)[19] allocated to the flight.

Step 6D Baggage is then taken by airside vehicle (baggage tug) to the aircraft side ready for loading into the aircraft.

Step 7D Baggage is loaded into the aircraft once it has been confirmed that the passenger manifest, and BHS input and output records reconcile with one another.

[17] Racetrack: Rotating conveyor device that stores ATL baggage pending flight build.
[18] Chute: Inclined steel framed roller bed that will statically store outbound ATL baggage pending flight build.
[19] Flight lateral: Horizontal powered conveyor or unpowered rollerbed that will statically store outbound ATL baggage pending flight build.

This process is known as “AAA reconciliation”.

Smaller commercial aircraft are typically those less than or equal to ICAO Code C. Usually with few exceptions, these smaller aircraft have loose loaded baggage which is manually unloaded from the loose load baggage cart and transferred into the aircraft baggage hold.

The medium and large aircraft are typically those equal to or greater than those classified by ICAO Code D, E and F. These larger aircraft utilize containerized (ULD) hold baggage equipment. The ULDs are built in the baggage hall, and lifted and positioned into the aircraft hold, and removed at the destination airport.

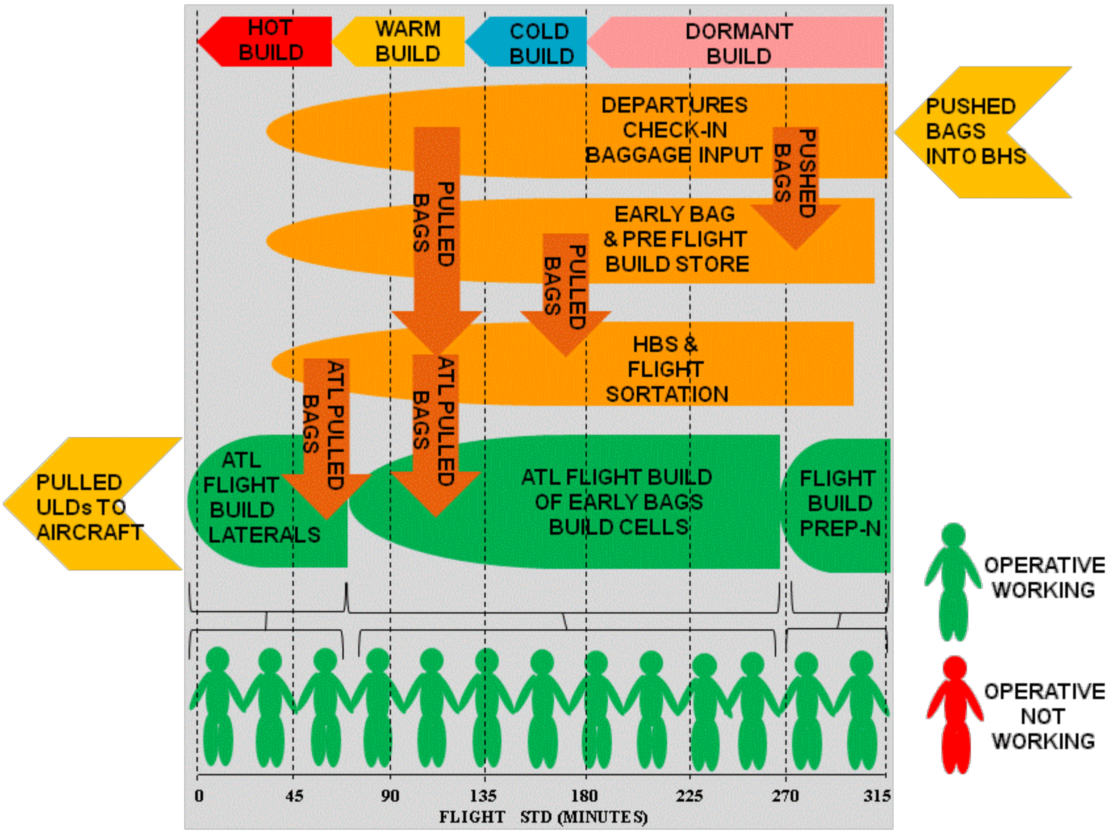
The current concept for processing transferring baggage is as follows:-

Step 1T[20] Baggage is removed from the aircraft hold either within ULD containers, or as loose loaded baggage. Loose loaded baggage is removed individually and placed into waiting baggage carts. The baggage carts or ULD containers are then driven to the airport BHS hall. Then in both instances the transfer baggage is separated from the arriving baggage manually.

Step 2T Transfer baggage is then injected into the departures processes at step 2D and then dealt with as departures baggage.

[20] Step #T denotes step number # of the Transfer baggage process

Figure 5: Advanced semi and fully automated build BHS (departures & transfer functions), steps 1D to 5D & steps 1T to 2T, push & pull operating model



1.9 Thesis structure

Chapter 1 provides an introduction to the research and describes the resultant research aim and objective questions that have emerged from the review of literature. Chapter 1 proposes that to answer the aims, and objectives of the PhD, it was necessary to create a model environment, and complete a series of experiments.

Chapter 2 examines the referenced academic, and industry research papers that have been obtained following study of the core, and surrounding literature material that has been identified. Capital financial appraisal methods are examined for relevance, baggage processing technologies, and processes are investigated, as are the baggage operational processes that are needed within current established, and recently introduced BHS solutions used worldwide. Chapter 2 describes the new fully automatic flight build technology option that has recently emerged, and what the perceived benefits are. Chapter 2 also defines common terminology that is referred to throughout the thesis.

Chapter 3 identifies the baggage handling technologies which exist, and those that are referenced within the model. The processing rate capabilities of all of the components that have been referenced within the model are given. The area of each of the baggage system components that are referenced is provided.

Chapter 4 describes, and explains the operational methodology used to answer the research aim. The analytical technique which creates realistic bags/hour demand profiles for the various long haul and short haul flight schedule demand scenarios is defined.

Chapter 5 clarifies how the capital and operating costs of the baggage handling equipment and the building is calculated, and the calculation and logic that defines the WLCC NPV calculation. This Chapter also describes the experiments, and the rationale behind them, that has ultimately answered the research aim.

Chapter 6 details, and itemises the results that have been obtained from the experiments using the model, and provides graphical representation of the results.

The penultimate Chapter 7 provides a discussion of the main findings from within the context of the researched literature. This Chapter also provides an analysis of the results, and a detailed explanation of how it answers the research question.

Chapter 8 contains the overall conclusion statements that relate to the study area, summarising the key points, and provides concluding recommendations. This Chapter suggests additional avenues of investigation that could be of use to the aviation industry, and highlights the limitations of the research with respect to health and safety issues.

2. LITERATURE REVIEW

2.1 Literature review introduction

The purpose of this Chapter is to explain what existing relevant literature exists in the research field. This Chapter also defines key concepts, and terminology that are referenced throughout this thesis. The literature review process identified 183 articles which were obtained from published academic journals, technical books, and published papers. The literature review identified the operational requirements stated by ICAO in Annex 17, and by IATA, in the Resolutions Manual, that a piece of hold baggage should only be built, when the airline has allocated the bag the status known as ATL[21]. The review identified the IATA (2004) Airport Development Reference Manual recommended processes, and equipment used within the design of BHSs. The review also identified the alternative financial appraisal techniques (FAT) models which can be used to compare capital developments.

This Chapter consists of nine main sections. The first section defines the financial appraisal methods that are used by airport operators, and development managers when evaluating the viability of airport system solutions. The second section explains what baggage processing technology is available, and how these technologies are categorized by the aviation industry. The third section details the established practice, and the latest practice BHS processes that are in operation across the world. Section four looks at what information has been published on capital, and operating costs of BHSs. The fifth section provides an insight to the equipment utilisation dilemmas that surround the use of semi-automated, and fully automated baggage loading

[21] ATL abbreviation, Authorised to load: status set by the airlines that permits hold baggage to be loaded into containers or baggage carts.

components, and the sixth section explains the new technology challenges. Section seven explains the processing time that is needed to build a ULD device using manual build. Section eight explains the time cycle issues that surround the processing of automated build. Finally section nine provides a conclusion to this Chapter.

2.2 Financial appraisal methods

Baggage handling systems are expensive to build, and to operate. Airport operators use financial appraisal tools to understand the financial advantages, and disadvantages of capital investment options that are presented.

There are many well established financial appraisal tools and metrics that can be considered, such as; net present value (NPV[22]), Nopper and Hompel (2010), Purnell et al, (2012) , Briscoe , (1990), Haste Doug (2014), Barrow, (2012), weighted average cost of capital (WACC[23]) Burke (2006) , internal rate of return (IRR[24]), payback period[25], and earnings before interest, taxes, depreciation, and amortization (EBITDA[26]) methods. The main parameters that are entered into these financial appraisal tools are: (i) Capital cost invested per annum; (ii) Operating cost forecasted per annum; (iii) Forecasted incremental revenue generation, realized per annum resulting from the implementation of the investment, and (iv) Asset residual values. These financial appraisal tools are often referred to as financial appraisal technique

[22] Net Present Value (NPV) - This is a discounted cash flow (DCF) technique. The NPV of project is the summation of the initial investment, and the present day values of the future cash flows established using a discount rate. The NPV value that is generated is the WLCC profit from the project.

[23] Weighted Average Cost of Capital - This is a method that can calculate the minimum financial income that is required to be earned on an asset.

[24] Internal Rate of Return (IRR) - This is a DCF technique as described by NPV, the discount rate used will achieve an NPV which equates to zero (at the break even point).

[25] Payback Period - Payback period the period of time required for the return on an investment to repay the cost of the original investment.

[26] Earnings before interest, taxes, depreciation, and amortization (EBITDA) - A cash flow tool that uses costs and revenue earnings before the deduction of interest, expenses, taxes, depreciation, and amortization.

(FAT) tools; FAT tools are widely used in commercial industry, including the airport development sector. Examples of the use of these models have been seen within the researched literature of Brathen et al (2000), Vasigh et al, (1998), and the BAA airport finance department, (2007). Whilst FAT tools can predict cash flow outcomes, it is widely acknowledged that FAT tools have limitations. They cannot be used to predict the operational viability of a product or service, merely the financial ramifications resulting from an expected pre-known product or service performance. Cost of borrowing assumptions as seen in the paper by Brathen et al (2000) and Turner and Morrell, (2003) can have a significant effect on the predicted financial viability of compared options. Asset residual values need to be declared at the end of commercial evaluation period.

The capital cost of baggage handling equipment varies from supplier to supplier, and from region to region of the world. Benchmarking of equipment costs, as seen in the papers by Francisa et al, (2002), Wood, (2010), and Unwin, (2009) have been used to create a generic equipment cost database.

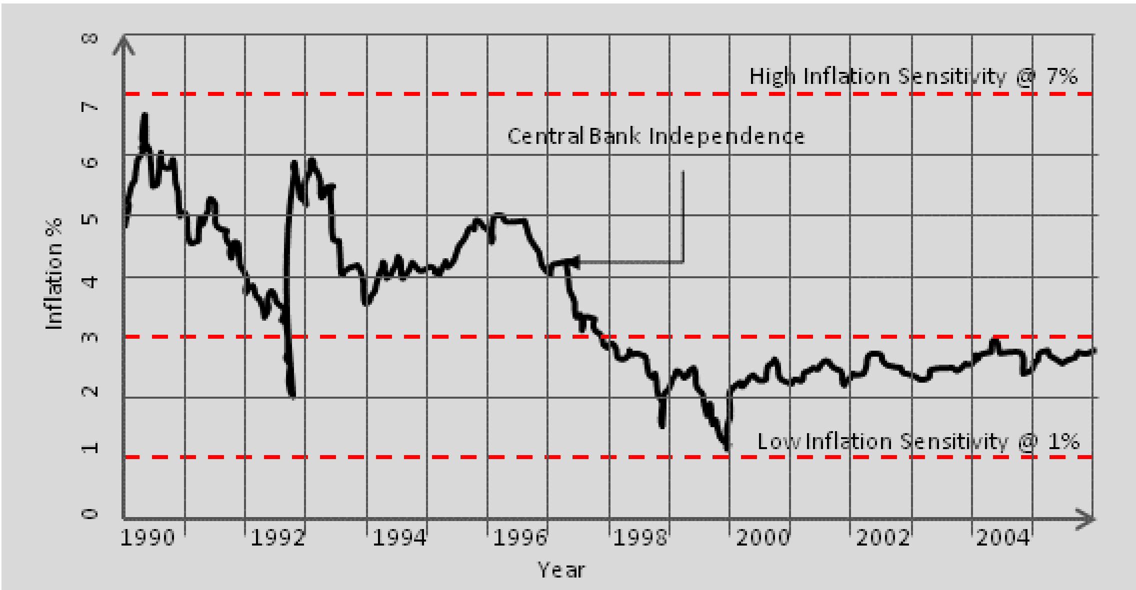
The operating cost of BHSs also varies from system to system, depending on the system capacity, the type of components that is used, the resultant size of the BHSs, and the quantity of staff that are used. The region of the world where the baggage system is to operate also dictates the regional staff salary variances, and the energy commodity prices. These factors are explained in section 2.5, and are programmed into the model. Major airport operators use FAT tools which calculate the IRR, EBITDA, and WLCC NPV when considering any major capital development.

2.2.1 Inflation ranges

Baggage handling systems operate over many years, indeed in some instances over many decades. It then follows that the capital, and the operating costs of these BHSs need to take into consideration the effects of inflation over prolonged periods, as described by Gürkaynak S, et al (2010). Inflation can have a significant effect on the outturn cost of a BHS project, and it is for this reason that inflation must be taken into account during the experimentation stage. The model has been subjected to three inflation rates during the experimentation stage, these are inflation rates of: 1% (low inflation), 3% (base inflation), and 7% (high inflation). Recent UK historic inflation ranges were stated by Gürkaynak S, et al (2010), see Figure 6, which relate to statistics originally generated by the UK Office of National Statistics. UK inflation statistics are referenced as the model generates all capital and operating costs in £'sterling as the base currency.

Figure 6: Inflation Sensitivity: "The evolution of far-ahead forward inflation compensation in the United Kingdom, 1990– 2005."

Source: Gürkaynak S, Levin Andrew, Swanson Eric (2010)



2.3 Baggage processing technology

The technology used in airports to check-in, transport, security screen, and sort departing hold baggage is constantly evolving. IATA, (2004), categorises these technologies into three main codes of baggage systems. These codes are defined as:

(i) Category A: Baggage systems which process relatively low baggage flow rates of less than 999bags/hour. They use comparatively low complexity technology, often encompassing manual sortation systems as identified by Abdelghanya, (2006).

(ii) Category B: These baggage systems process bag flow rates within the range of 1000bags/hour to 4999bags/hour. To process these higher rates reliably, it is necessary to employ automated sortation technology such as tilt tray sorter equipment; as the flow rate reaches the maximum flow rate range, the use of directly controlled vehicle (DCV) technology is recommended by IATA (2004). There are many airports worldwide which use these technology solutions. An example of the DCV technology is referenced within the paper relating to Denver airport automated baggage handling system prepared by SITA, (2008), and the sorter technology referenced within the paper relating to Paris Charles de Gaulle airport prepared by Ott, (2009).

(iii) Category C: These are baggage systems categorised by the highest baggage flow of greater than 4999bags/hour. With these bag flow rates it is necessary to use high quality sortation system technology. DCV equipment is recommended by IATA, (2004) for these, often very large, airport baggage systems.

The IATA best practice guidelines were developed, and published in 2004. The Category B and C system guidelines do not reference leading edge technologies that can be described as automated "build cells"[27]. These include the robotic solutions as defined by ISO8373 in International Organization for Standardization (1994), and automated baggage containerisation, "bagtruck", technologies as described by Robuste and Daganzo, (1992). Category C high baggage flow rate sorter system equipment is evident in many airport developments, and live baggage system halls, as noted by Rijsenbrij and Ottjes, (2007).

Automated build cells, such as the robotic solutions used in Amsterdam airport noted in the paper composed by Samola, (2008), benefit considerably from the use of single handler operation. There are legislative limitations in Europe to the use of a single handler across any commercial European airports. European Union, (1996) legislation imposes restrictions on the airport companies in this regard. The practical advantages of using a single handler for management of multiple automated build cells presents predominantly operational cost saving opportunities, and increased work rate opportunities to the airlines using such technology.

The IATA system category guidelines refer mainly to the mechanical systems being employed, and do not reference the Information Technology (IT) preferences as defined by SITA, (2008). All of the categories of baggage handling systems referenced by IATA, (2004) use in line hold baggage screening technology similar to that referenced by Feng, (2007), and incorporate in line hold baggage screening processes as identified by Virta, (2003).

[27] Build cell: zone within a baggage system used to build baggage into ULDs using robotics or mechanized build baggage loading technologies.

The baggage within conventional baggage handling systems is built using staff positioned at the output chutes[28], or laterals[29]. The rate by which the staff build the flights varies as outlined by Stewart, (2010) Dolye (2010), Shortland (2010), and Cowper (2010).

2.4 Baggage operational processes

All baggage handling systems process baggage following a set of standard baggage operational processes as defined by IATA (2004). There are common baggage process schematics which define the following functions:

(i) Baggage check-in;

(ii) Hold Baggage Screening (HBS);

(iii) Early baggage storage;

(iv) Early baggage flight build;

(v) Manual coding;

(vi) Problem bag resolution,

(vii) Flight sortation, and

(viii) Flight build.

The check-in process can take many forms, such as conventional check-in desks referenced by Robuste and Daganzo, (1992), self-service kiosks/bag drops and remote check-in (including home/downtown/railhead check-in) as noted by Business Travel News Weekly (2007). All of these forms of check-in, with the exception of remote home check-in, incorporate common user terminal equipment (CUTE) as noted by Hamzawi, (1992). The CUTE check-in technology increases the efficiency of the use

[28] Chute: 20-45 degree roller bed device that stores departing hold baggage by flight and segregation.
[29] Lateral: horizontal conveyor device that stores departing hold baggage by flight and segregation.

of check-in resources, and provides the flexibility for an airport to allocate, and then reallocate a check-in desk position to any airline rapidly throughout the operational day. This is done by providing common airline systems, and dynamic airline / flight identity signage.

The Hold Baggage Screening (HBS) process is used to comply with national aviation legislation, which originates from the ICAO Annex 17 standard. The process involves the X-ray screening of hold baggage whilst the baggage is in transit. National authorities, and IATA, (2004) state which best practice HBS processes that should be used. HBS can be completed using X-ray screening processes as denoted by Feng, (2007) and Computer Tomography process technologies, and parameters denoted by Kelly and Rongfang, (2005) also by using equipment as defined Jacobson et al, (2003).

Early baggage storage (EBS) systems have two main functions. The first function is to hold bags that have been inserted into the baggage system in advance of the flight being ready for build. The second function is to prepare batches of bags that are to be built as outlined by Oehjo, (2010), or by using robotics as reported by Samola, (2008). Section U4 of the IATA (2004) airport development reference manual details the processes used in conventional early baggage systems. The operational processes described in this manual are the de facto current standard. The second function is not referenced within the IATA manual, as this process was developed after the publication date of the IATA manual.

Manual flight sortation is carried out using racetrack/reclaim sorter units, and is a manually intensive process. Automatic flight sortation is carried out using tilt tray sorter product, as defined by Sorak, (2007), or DCV technology as outlined by Justin et al, (2005), and Tarău et al (2011). These units use the data on the baggage labels, and then automatically route baggage to the correct flight output device such as a lateral units or chute units.

2.5 Capital and operating costs of baggage systems

2.5.1 Capital costs

The capital cost of a baggage handling system is a summation of the costs of the baggage system components needed to process the forecasted demand. Benchmarked baggage system component capital costs are available from Wood, (2010), Unwin, (2009), Feng, (2007), Mackenzie-Williams, (2005), and Byrd and Cochran, (2007). With the exception of the data from Wood (2010), the remaining data is quite old and relates to conventional baggage handling systems equipment only sold within the UK. This data has now been refreshed, and includes the newer automated build technologies, such as robotics, as noted by Husted and Broderick, (2006). The cost of a baggage system shall also vary according to the quantity, type and manufacturer of the baggage handling equipment used.

The forecasted demand is influenced considerably by the capacity of the aircraft stands that support, and surround the baggage hall. The maximum forecasted demand shall be achieved if the stand utilization is optimized, as explained by Haghani, and Chen, (1998). Baggage demand is usually forecasted using theoretical demand models. Kelly and Rongfang, (2005) use a stand planning model which dictates the aircraft codes that can be accommodated on the apron simultaneously. The number of passengers on these aircraft, are then multiplied by the bag to passenger ratio. This then defines the potential maximum baggage flow rate demand forecast that the baggage system must be able to deal with. The capital cost of the baggage handling system can be represented as an equation, as documented by Wen-Hsien, and Lopin Kuo, (2004) and Jacobson et al, (2003).

2.5.2 Operating costs

The quantity of mechanized components, and in particular the quantity of automated build components, instead of conventional build components shall determine the number of handler operatives, and the operational maintenance team, that is required to support the operation of the baggage system. The overall baggage system operating cost calculation is outlined by Briggs, (2009). HBS staff costs are also a significant operating cost which must be accounted for, as outlined by Butler and Poole, (2002). Less automatic systems are generally the preference of low cost carriers, the operating costs of which are reported by Tsoukalas et al, (2008). Manual baggage systems are often operated by single or multiple handling agent companies as they are essentially manual sortation processes where the operator pulls a bag off of a system. More complex automated baggage handling systems generally tend to favor the use of the single handler operation if the maximum efficiencies are to be obtained. In both manual, and automatic systems, and within the confines of the jurisdiction of European Union, the law imposes restrictions on the use of a single handler. Tardy, (2007), and SH&E, (2002) have reported the costs of single ground handling operations. A baggage system which needs to be operated by multiple handlers can be significantly more expensive to build, and to operate. In addition to this, staff costs vary considerably from country to country both within, and outside of the EU.

Airline operating costs have been documented in the papers produced by Alamdari et al, (1997), Sarkis, (2000), Banker et al (1993), Franke (2004), and Forsyth et al (2011). These papers use estimated and generalized annual staff salaries. All of the salaries quoted are specific to the region of the world that the paper is written at a historic period in time. It is necessary to be able to adjust this staff cost to any region of the world using regional data adjustment factors as defined by IATA (2004), and to be able to apply present day staff costs. This enabled the FAT tool to produce meaningful present day (Quarter 4, 2011) financial output assessments.

2.6 New technology challenges

This section explains what physical, and social challenges exist when trying to implement the new pull BHS process technologies, and how this will present challenges to airports, and airlines that are trying to reduce capital and operating costs.

The semi-automated, and the fully automated baggage build components both require substantial supporting conveyor hardware (input queuing conveyors, and output conveyors) to enable them to operate effectively; they also require the upstream bag store process to be positioned within a specified distance from the g1, and g2 components. Ideally the input to the components g1, and g2 should be no more than 2 minutes bag travel time away Oehjo.D, (2010), from the output from the baggage store process. This is required to ensure that the g1, and g2 components have the minimum downtime between ULD build cycles. To enable the g1, and g2 components to be fully occupied, and to have the minimum amount of build errors it is necessary to release a full batch of bags for a particular ULD, that have already been volumetrically scanned, and so it is pre-confirmed upon arrival at the g1/g2 cells that all bags in the bag batch can theoretically fit into the prescribed ULD, or loose load container. This constraint places considerable pressure on designers that are trying to position this equipment within BHS halls, particularly if it is an existing BHS building.

Another very real challenge is that baggage handlers can view the use of semi-automated, and fully automated build technologies as a threat upon their job security. This is turn can create a reluctance to use, and / or specify such technologies, as per the robotic systems specified at Amsterdam airport, Samola Betty, (2008). To combat this “people issue” it is necessary to engage the workforce, and use the opportunity to up skill workers to do more rewarding tasks.

The pull processes that are associated with the use of new semi-automatic build, and fully automatic build technologies have installation, commercial, and potentially social impact issues. The social impact issue associated with the implementation of these types of technology is not part of the scope of this research. The reasons why this issue has been excluded from the investigation are:

(i) There is no published information in this regard that can be analyzed;

(ii) There are only two installations in the world where this equipment has been installed so far, and only one (AMS) is currently operational;

(iii) Arguably the performance of the fully automatic solution is not affected by social impact issues as the machines build the flight automatically without human intervention (excludes fault fixing and topping up processes).

The physical installation, and resulting commercial impact are investigated in the following Chapters.

2.7 Manual build processing time

This section explains how long it takes to process 40 bags into a commonly used AKE[30] IATA (2004) ULD container using a single operative, and a set of prescribed manual flight build components.

The time it takes to manually build a ULD or loose load container is a function of:

(i) the number bags to be inserted within a prescribed ULD or loose load baggage cart, e.g. 40 bags / AKE ULD – IATA (2004);

(ii) the manual processing rate of the staff (See Appendix G – staff data base) that lift bags from the manual racetrack component (e.g. 2 bags/min/operator sustainable rate), and place them into a ULD or loose load container. This includes the time taken to complete the ATL reconciliation process;

(iii) the time taken to process one bag is denoted by the steps:

Step 1 Hand held flight bar code scan	5 seconds
Step 2 Walk bag to ULD	5 seconds
Step 3 Manual Flight Build	20 seconds
Total time to process 1 bag	30 seconds

[30] AKE: Definition - The IATA coding name given to the most common ULD size. This ULD size also goes by the former name of LD3.

At the above rate a single staff baggage build loader could take 20 minutes to build a single AKE ULD. Appendix G provides staff loading performance data from multiple sources. The rate that an operator can load baggage can vary enormously from person to person, and from country to country. For this reason the staff processing rate used is an average obtained from multiple airlines, and airport operators; the manual build rate is one of the test sensitivities that has been applied to the model.

2.8 Automated build processing time

This section explains how long it takes to process 40 bags into a commonly used AKE IATA (2004) ULD container using either (i) a single robotic g1 Samola Betty, (2008) component, or (ii) a single semi-automated RTT g2 component.

The time it takes to semi-automatically build a ULD or loose load container is a function of:

(i) the number bags to be inserted within a prescribed ULD or loose load baggage cart, e.g. 40 bags / AKE ULD – IATA (2004);

(ii) the processing rate of the semi-automatic loading device is 6 bags/minute/unit. This includes the time taken to complete the ATL reconciliation process.

(iii) the time taken to process one bag is denoted by the steps:

Step 1 Flight bar code scan	2 seconds
Step 2 RTT Flight Build	8 seconds
Total time to process 1 bag	10 seconds

At the above rate a single semi-automatic baggage build component could take 6.7 minutes to build a single AKE ULD. This ULD build rate is dependent upon staff motivation, however staff fatigue associated with physically lifting bags is reduced/removed.

The time it takes to fully automatically build a ULD or loose load container is a function of:

(i) the number bags to be inserted within a prescribed ULD or loose load baggage cart, e.g. 40 bags / AKE ULD – IATA (2004);

(ii) the processing rate of the fully-automatic loading device is 4 bags/minute/unit. This includes the time taken to complete the ATL reconciliation process.

(iii) Where time taken to process one bag is denoted by the steps

Step 1 Flight bar code scan	2 seconds
Step 2 Robot Flight Build	13 seconds
Total time to process 1 bag	15 seconds

At the above rate a single fully automatic robotic baggage build component could take 10 minutes to build a single full AKE ULD. This build rate is not reliant on staff motivation. It should be noted that currently the robotic solution requires the last 3-4 bags within a container to be manually built, as the robotic arm cannot often insert these last few bags into the ULD if they have a ceiling on the ULD, which is predominantly the case.

Clearly operationally the semi-automatic build technology offers the highest throughput rate. This is working on the basis that the operator is personally motivated to point and direct this staff operated technology constantly, when compared to the fully automated robotic solution which does not need an operator to load 90% of the ULD space. Operationally the manual operator is comparatively slow, and is more susceptible to throughput variations.

2.9 Chapter summary

The literature review Chapter identified what knowledge currently exists to support the aim of the PhD, and what gaps in knowledge are present pertaining to the financial comparison of manual BHSs, and semi-automated BHSs, and Fully automatic BHSs.

It is apparent that relevant supporting information and papers exists that were of use in the development of the model, which in turn was used to answer the aim of this PhD. None of the currently published information alone answers the fundamental aim of this research.

The data obtained during the literature review stage has been documented, and is referenced within the model that is explained in the following Chapter 3. The results of the tests carried out using the model have then been assessed, and the conclusion made in Chapter 8 of this thesis.

3. MODEL ELECTRO-MECHANICAL COMPONENTS

3.1 Research questions

This Chapter explains how information obtained from the literature review process has been incorporated into the model. This chapter also provides a detailed explanation of how the model has been derived. It is proposed that by using this model, which incorporates consistent BHS component assembly logic, this produces a common platform by which to generate valuable WLCC NPV data. Such data can and has been used to help answer the PhD aim.

All BHSs contain electro-mechanical components to enable them to function. There are no off the shelf models that can be used to describe the various BHSs. Therefore to successfully construct a model it was first necessary to ask oneself a series of questions that relate to these electro mechanical systems. These questions were noted to be:

(i) What components would be needed in a BHS environment?

(ii) What processes and rules would be needed to describe a BHS environment?

(iii) What data is required in a BHS environment?

(iv) What BHS technologies should be assessed in a BHS environment?

A BHS model environment is proposed, and constructed to fundamentally answer question 1. The model consistently assembles BHSs using best practice guidelines from IATA (2004), and is supported by real capital cost, and energy consumption, and maintenance running cost data for the selected BHS components. The model provides a tool that enables any BHS capacity, location, and common equipment to be compared consistently for incremental BHS throughput demands.

The model incorporates a WLCC NPV calculation module which is the metric used to define which BHS solution is determined to be the best (first ranked), next best (second ranked), and least best (third ranked).

The model allows test results to be produced in the knowledge that the approach, and assumptions defined in this Chapter are consistently applied and are independent of distorting factors such as, though not limited to:

(i) varying profit margins applied to BHS developments (buildings and BHS);

(ii) the impact associated with developing a BHS into an existing baggage hall, and being able to realistically extract factually accurate costs for a truly accurate comparison.

3.1.1 What components would be needed in a BHS environment?

There are many component types that can be used in a BHS, from baggage input check-in conveyors to baggage output laterals. The components that have been selected and referenced within the model are the most common components, as described by IATA (2004) within the Chapter U of the Airport Development Reference Manual. The exception to these IATA referenced components, are the ULD movement devices (Component f2 ULD Powered Rollerbed), the robotic build devices (Component g1 Robotic Build Cell), and the semi-automated build device (Component g2 RTT (Teleair) Semi-automated build Cell).

3.1.2 What processes and rules would be needed to describe a BHS environment?

During the literature review stage, the commonly used “push based” BHS processes, and the “pull based” BHS processes, considered to be “cutting edge” BHS processes, were identified (see section 1.8). These generic level processes do not however provide sufficient detail to enable a BHS to be specified in detail. Overview and detailed level process schematics were then developed, which align to the requirements of both push based systems for the manual BHS solution (see Figure 67 and Figure 68), and the pull based semi-automatic BHS (see Figure 70 and Figure 71), and the pull based fully automatic (see Figure 73 and Figure 74) BHSs. The selection of components that were used within the model is set by rules that cross reference to these process maps.

3.1.3 What data is required in a BHS environment?

To enable a BHS environment to be constructed within a model, it is necessary to construct the BHS components within the model, bottom up. That is, every major component that is needed to convey the demand must have:

(i) Component throughput performance bag/min rate;

(ii) Capital costs;

(iii) Energy consumption parameters;

(iv) Maintenance cost variables and;

(v) Footprint area,

for each of the BHS types. Appendix C is the equipment dbase worksheet, this contains all of the data needed for each of the components listed within section 3.3.1.

3.1.4 What BHS technologies should be assessed in a BHS environment?

The common departures BHS technologies defined by IATA (2004) in Chapter U of the Airport Development Reference Manual have been referenced within the model. The IATA manual went to press before the newer pull process technologies were readily available. It is necessary to include these additional semi and fully automated flight build technologies (see Figure 24 and Figure 25) as they are fundamental to the aim of the investigation study and underpin it.

3.2 Model component equation development

3.2.1 Model structure

This section explains in detail how the model has been constructed and completed. The component blocks are discussed and details of the actual geometric forms that are programmed into the model are provided.

The model is constructed and programmed using Microsoft Excel software. It contains a series of interdependent worksheets which enable manual, semi-automatic and fully automatic BHSs and their corresponding buildings to be constructed. Examples of the rules being applied to define the quantity of components can be seen in Appendix A.

Figure 7 explains the relationship between the various worksheets present within the model, and the data flow between them. The worksheet list below provides the step by step sequence that must be followed to create the WLCC NPV data for each of the

BHS inputs being considered. A functionality statement is also provided for each worksheet.

STEP[31] 1 Data gathering

(i) Input Variables;

Function: permits the aircraft demand profile and airport geographic location data to be entered into the model.

(ii) Gamma Distribution[32];

Function: calculates the baggage flow vs time distribution of a single flight within the model.

(iii) Peaking Factor;

Function: calculates the peak flow rate factor to multiply the bags/hour rate by, when all of the flights are assembled into an hour period flight schedule.

(iv) Country & Inflation Dbase;

Function: Reference tables used by the assembly environment, which contain the IATA CAPEX and OPEX adjustment factors – IATA (2004) Chapter D5. These values can be used to inflate or contract the CAPEX and OPEX values accordingly.

(v) Equipment Dbase;

Function: contains the BHS equipment size, cost and performance data that is referenced by the assembly environment worksheet.

(vi) Staff Dbase;

Function: reference tables used by the assembly environment worksheet, which contain the staff operating costs, and staff operating performance data.

[31] See figure 7 for process step sequence position

[32] Gamma distribution: Flow of baggage, per flight, into a baggage handling system can be predicted using the mathematical equation commonly known as the “Gamma distribution” equation.

(vii) Reference Cost Plan;

Function: reference cost plan used to calculate the project “on-costs” or preliminary costs that should be applied to the capital costs.

STEP 2 Development of the solutions

(viii) Assembly Environment;

Function: contains the design, capital cost, and operating cost BHS design logic that generates the three BHS build solutions.

(ix) WLCM;

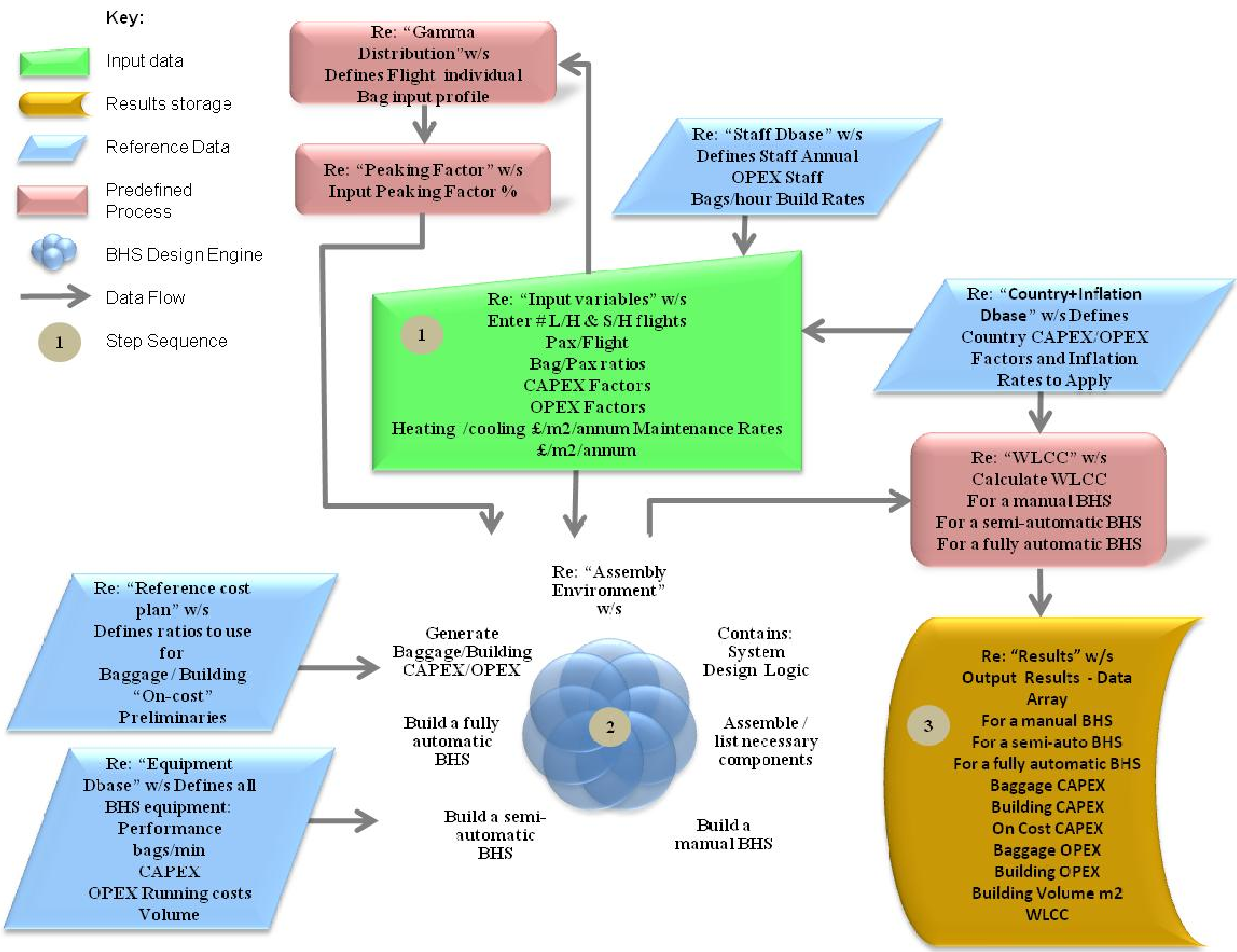
Function: references the capital and operating costs generated from the assembly environment worksheet, and creates the 15 year point whole life cycle cost.

STEP 3 Collation of the results

(x) Results.

Function: collates experimentation results data and stores this in a data array.

Figure 7: Model structure and interfaces



3.3 Model: mechanical volumetric blocks

3.3.1 Components overview

Figure 8 to Figure 25 inclusive define the set of geometric BHS equipment forms that have been programmed into the model equipment dbase worksheet, which in turn are referenced in the assembly environment worksheet. The full set of components and resources that are referenced within the model are tabulated as follows:

Table 1: Full list of model components

Component ID	System Function	Sub System Technology	Present with following BHS: Fully Automatic	Semi-Automatic	Manual
a1	Check-in	Conventional Conveyor (3x1.2m assembly)	Yes[33]	Yes	Yes
b1	Delivery	Collector Belt (1x20m)	Yes	Yes	Yes
b4	Delivery	Powered Belt Curve	Yes	Yes	Yes
c1	Early Baggage Store	Conveyor Lane Q conveyors (1x1.2m)	Yes	Yes	Yes
d1	Hold Baggage Screening	Standard 2 Level 1 Unit	Yes	Yes	Yes
d2	Hold Baggage Screening	Standard 2 Level 3 Unit 5% reject rate	Yes	Yes	Yes
d3	Hold Baggage Screening	Standard 2 Level 2 Workstation 20% reject rate	Yes	Yes	Yes
e1	Flight Sortation	Flight Lateral (1x28m)	Yes 75%	Yes 75%	No[34]
e3	Flight Sortation	Flight Racetracks (1x40m length unit)	No	No	Yes 100%
e9	Flight Sortation	Divert VSU	Yes	Yes	Yes
e10	Flight Sortation	Indexing	Yes	Yes	Yes
e11	Flight Sortation	Sortation induct	Yes	Yes	No
e12	Flight Sortation	Sortation loop (10m per lateral pitch needed)	Yes	Yes	No
e21	Flight Sortation	Power bus (1 off assembly) unit	Yes	Yes	Yes
e22	Flight Sortation	Scanner array	Yes	Yes	Yes
f2	Flight Sortation	ULD Powered Rollerbed	Yes	Yes	Yes
g1	Mechanized ULD Build	Robotics (Grenzebach)	Yes 25%	No	No
g2	Mechanized ULD Build	Manipulator (RTT type unit)	No	Yes 25%	No
h1	Power	Power Conditioner (1 off per facility)	Yes	Yes	Yes
h2	Power	Power Incomer (1 off per drive)	Yes	Yes	Yes
h3	Power	Motor Controllers (1 off)	Yes	Yes	Yes
h4	IT	Programmable Controller Computer	Yes	Yes	Yes
h5	IT	Programmable Controller Module	Yes	Yes	Yes
h6	IT	Programmable Controller Software (1 off system cost)	Yes	Yes	Yes
h7	IT	Sort Allocation Computer (1 off Unit and software)	Yes	Yes	Yes
h8	IT	Control System Computer and Display	Yes	Yes	Yes
h9	IT	Safety Equipment (per drive)	Yes	Yes	Yes
h10	IT	Network (per installation)	Yes	Yes	Yes
h11	IT	SCADA system (base hardware / software)	Yes	Yes	Yes
i1	Handling Agent	Manual loader (lateral /racetrack/ chute)	Yes 75%	Yes 75%	Yes 100%
i2	Handling Agent	Manual loader (Robotics support & top up)	Yes 25%	No	No
i3	Handling Agent	Manual loader (RTT)	No	Yes 25%	No
j1	Steel work	Platform (per m run)	Yes	Yes	Yes
j3	Steel work	Stairs (per ladder)	Yes	Yes	Yes
k1	Sub equipment	Fire door (per door)	Yes	Yes	Yes

[33] "Yes" denotes function present with BHS type
[34] "No" denotes function not present with BHS type

The scale and form of the components that follow have been established from the IATA (2004) Airport Development Reference Manual Chapter U. In the situation of HBS equipment a maximum equipment size has been used. With respect to the early bag store solution a lane based queue conveyor solution has been accounted for. This is represented by the use of component “c1 Early Bag Store single Q Conveyor”.

There are three considerations that should be noted with regards to the definition of the early bag store (EBS) solution used within the model:

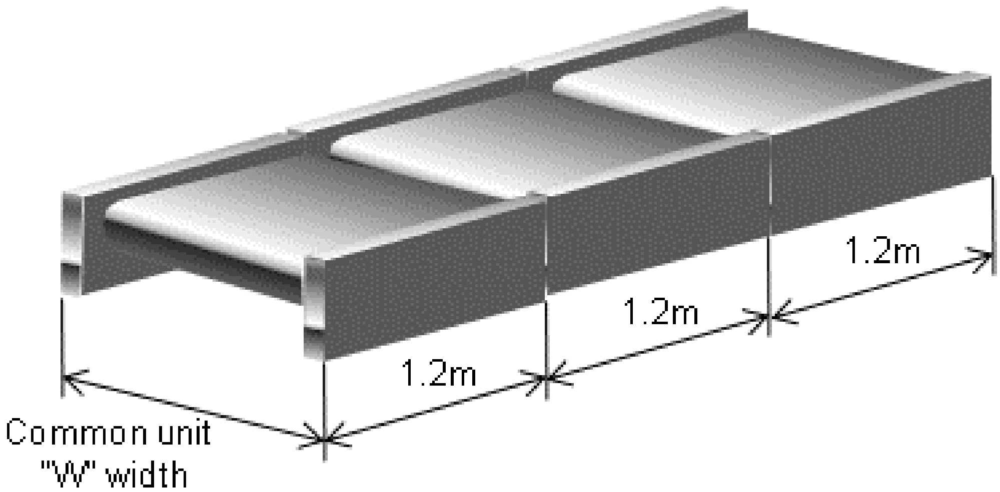
(i) the quantity of c1 components used within the assembly environment is calculated by multiplying the peak demand Bags/Hour rate by a set 38%, this value has been used following discussion with the BHS consultants, as most operational BHSs that use EBS solution have a EBS which holds on average 38% of the input design rate;

(ii) there are two types of EBS solution, the lane conveyors as defined by component c1, and the crane and rack systems. The model does not account for the use of crane and rack EBS solutions. Like for like for the same sized EBS, the crane and rack EBS systems are reported by the manufacturers to occupy less space than the lane based c1 based product solution. It is for this reason that the maximum size solution has been referenced.

(iii) to define the system specific absolute correct sized EBS it is necessary to simulate the flows that would enter the EBS, using a discrete event simulation tool. This will confirm the size of the EBS taking into account the dynamic nature of baggage flows.

3.3.2 Component a1 check-in desk conveyors

Figure 8: Component a1 check-in desk conveyors



Function: This check-in desk arrangement is used on the departures concourse of all international and departures terminal buildings. It is the main mechanism to inject and input baggage into the BHS. Passenger and staff transfer baggage input has been excluded. There are essentially two variations of check-in desks, the conventional check-in desk, which is staff assisted, and the self-service bag drop, it is assumed that both have the same bags/hour throughput rate. Volumetrically the model contains the data for the check-in desk conveyors only. The total check-in component block usually comprises of the following sub-components, as denoted by IATA (2004):

- Check-in counter (excluded[35] volumetrically within the model);
- Desk control panel including CUTE[36] displays[37] (excluded volumetrically within the model);
- Weighing conveyor, incorporating scales;
- Label conveyor;
- Dispatch conveyor;

[35] Check-in counters are excluded as they are considered to be an architectural feature.
[36] CUTE: Abbreviation – Common User Terminal Equipment – Airline and flight display unit mounted around the check-in desk.
[37] Check-in CUTE displays are excluded as they are considered to be an architectural feature.

- Label printing facilities.

Once the check-in desk is opened and operational, the check-in conveyor then accepts departures baggage demand input into the BHS in a controlled manner, as denoted in the process maps Figure 68, Figure 71, Figure 74. The check-in desk component a1 processing flow rate is a function of: (i) passenger queue management; (ii) speed of the conveyors, and (iii) time taken to manually label the departing baggage with the IATA (2004) licence plate bag tags.

The quantity of component a1 used is defined by the equation:

$$Na1 = \frac{D}{Pa1} \qquad \text{... 1}$$

Where:

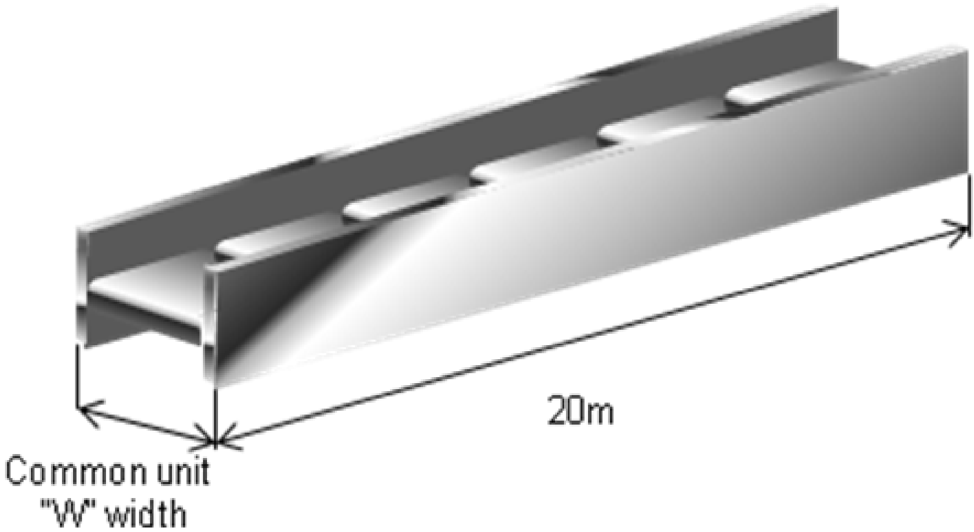
Na1 = The number of a1 components present

D = Demand = Bags/Min.

Pa1 = Processing rate of the component a1 = 0.67 Bags/Minute

3.3.3. Component b1 delivery conveyor

Figure 9: Component b1 delivery conveyor



Function: The delivery conveyor component is located after the check-in function block, as described in the processes outlined in Figure 68, Figure 71, and Figure 74. This conveyor can act as a throttle, thereby controlling the bag flow going through the entire BHS. There are essentially two types of delivery conveyor options: (i) Those where there is no controlled event discharge, and baggage injection from the check-in dispatch conveyors to the delivery conveyors is managed on a random basis, rather than by calculating free space on the delivery conveyor belt. In this situation the delivery conveyor is fitted with photocells before each check-in desk injection junction point. This reduces, though does not eliminate the possibility of baggage jams, and (ii) those where controlled event discharge is fitted and baggage injected from the check-in dispatch conveyor is controlled by the BHS PLC[38], this calculates the free window space on the delivery belt allowing effective injection from check-in. From a CAPEX, OPEX, and processing perspective the component b1 referenced a delivery conveyor which incorporates the controlled event discharge functionality.

The quantity of component b1 used is defined by the equation:

$$Nb1 = \frac{D}{Pb1} \qquad \text{... 2}$$

Where:

Nb1 = The number of b1 components present

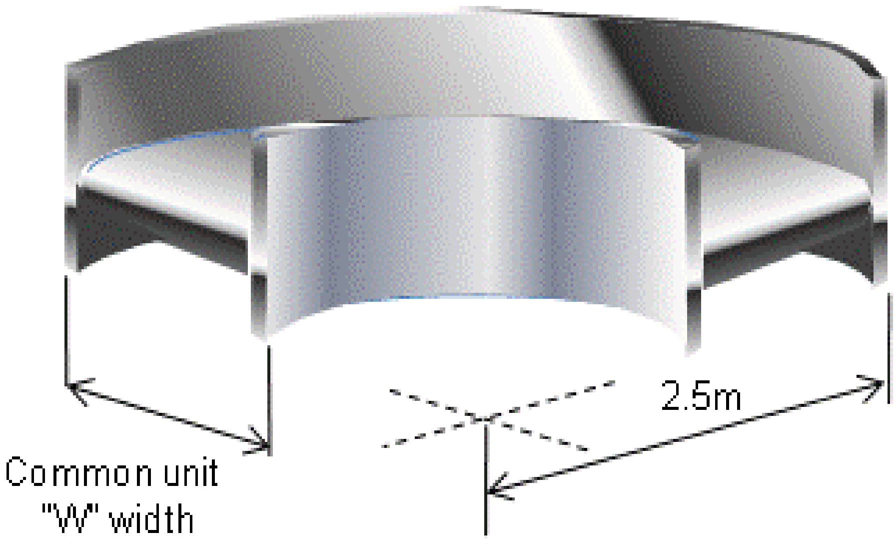
D = Demand = Bags/Min.

Pb1 = Processing rate of the component b1 = 25 Bags/Min.

[38] PLC: Abbreviation – Programmable Logic Controller – Computer that controls the operation of baggage conveyors.

3.3.4 Component b4 powered belt curve

Figure 10: Component b4 powered belt curve



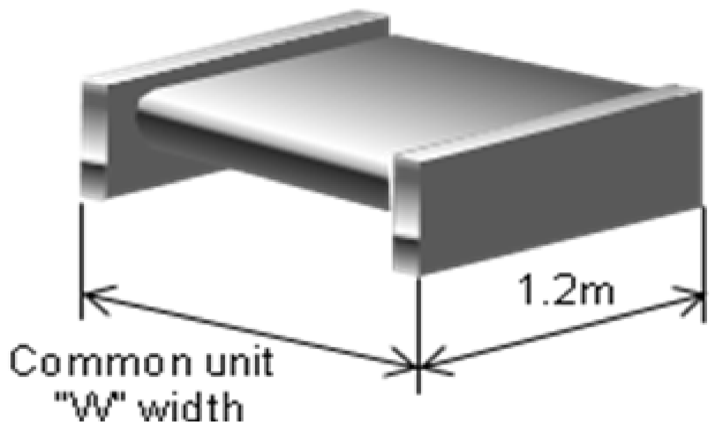
Function: The powered belt bend conveyor allows the baggage flow within all of the processes depicted within Figure 68, Figure 71, and Figure 74 to change direction smoothly. The model has been programmed to accommodate the installation of the 90 degree powered belt curve conveyor, though it should be noted that 45 and 90 degree conveyor bends are available as well as spiral incline and decline powered belt bends. These units are less commonplace, are expensive, and have not been referenced within the model. It is also possible to change flow direction using "T" or "L junctions, though IATA (2004) note that using these types of units can often create baggage snagging points, which in turn can create undesirable bag jams. It is for this reason that these types of directional change mechanisms have also not been included within the model.

The powered belt curve component b4 is often used to weave the baggage routes through baggage hall, missing columns, and heating and ventilation equipment infrastructure. Since the model does not create a real three dimensional model of the

BHS which would contain such infrastructure, it is necessary to make an experience based judgement on the likely quantity of direction changes needed within each flow route, from the input at Check-in (component a1) through to the output at the lateral (component e1), or the output racetrack (component e3), or the output robotic cell (component g1) or the output RTT unit (component g2). The model has been programmed to calculate that for any type of BHS (manual, semi- automatic or fully automatic), ten powered belt curve component b4s are provided for each delivery line conveyor b1 that is calculated to be required. This is a realistic representation of the likely quantity of component b4s that will be required based on over 20 years of experience of these systems.

3.3.5 Component c1 early bag store single Q conveyor

Figure 11: Component c1 early bag store single Q conveyor



Function: It can be seen from Table 2 that follows that there are two types of early bag store: (i) the lane based solution as defined as in Figure 11, and (ii) the crane, and rack based solution. The lane based solution occupies more space, and consumes more energy than the alternative crane, and rack based solution, and it is for this reason that this crane and rack technology solution has been omitted from the model.

A single component c1 has the ability to store a single bag. It can be seen in Table 2 that most modern BHSs need to store[39], in some instances thousands of bags simultaneously. The model is not a simulation model, which would be able to dynamically determine the true simultaneous demand placed on an early bag store, as a result of a specific flight schedule demand. Instead for the static model, one must define the relationship between historic BHS demand, and historic early bag store capacity needs, as these parameters are available.

Table 2 then denotes that on average, the quantity of bags that need to be stored in the bag store, which is calculated to be 38% of the demand (bags/hour) placed within the historic BHSs. The model then uses this 38% factor when determining the size of the EBS to incorporate. This means that for any sized BHS the quantity of component c1 required is described by the equation:

$$N\,c1 = D \times 38\% \qquad \ldots 3$$

Where:

Nc1 = Number of component c1 (Early Bag Store single Q Conveyor) present

D = Demand = Bags/Min.

[39] Bags are stored for two reasons: (i) the flight lateral or build cell is not open and bags cannot be built or (ii) to enable batching of bags in readiness to release to semi-automatic or fully automatic flight build process.

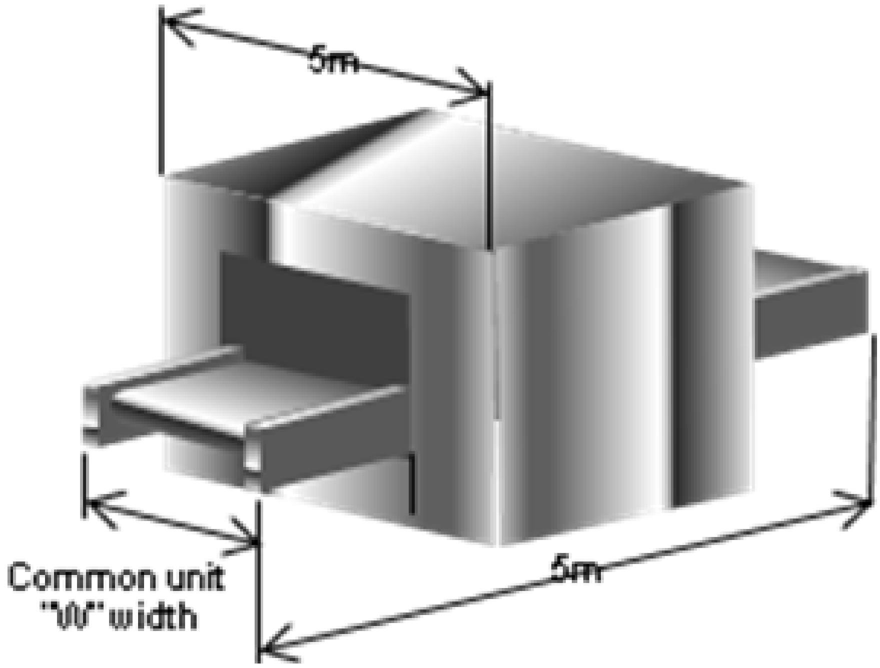
Table 2: Early bag store references

IATA Category	Location	Storage Positions	BHS Capacity	(Positions / BHS Capacity) %
B	Southern Europe	748	2100	36%
B	Middle Europe	2170	2800	77%
B	Middle Europe	2993	4000	75%
B	Southern Europe	1069	3900	27%
C	Middle Europe	4988	7000	71%
B	Far East	713	3500	20%
B	Middle Europe	143	1750	8%
C	Middle Europe	3421	5250	65%
C	Middle Europe	2850	6300	45%
B	Far East	713	3150	23%
C	Middle East	2850	6300	45%
B	Middle Europe	570	2800	20%
B	Northern Europe	239	1750	14%
B	Northern Europe	1603	3780	42%
B	Middle East	570	2100	27%
B	Middle Europe	385	3500	11%
			Average	**38%**

Source: Paul Bellamy BHS Consultant (2009)

3.3.6 Component d1/d2 hold baggage screening

Figure 12: Component d1/d2 hold baggage screening



Function: The hold baggage screening (HBS) process block is defined in Figure 68, Figure 71, and Figure 74. The component d1 is the Level 1 and 2 intelligent X-ray machine, and the component d2 is the Level 3 computer tomography X-ray machine.

Both of these components are designed to interrogate the contents of passengers' baggage whilst within the BHS, that is ultimately destined to be loaded into the hold of the aircraft. Those bags which fail level 1 screening proceed to Level 2 screening, those bags the clear level 1 proceed to the flight sortation process. Those bags that fail Level 2 proceed to Level 3 screening, and those bags that clear level 2 proceed to the flight sortation process. Those bags that fail Level 3 proceed to passenger reconciliation, and those bags that clear level 3 proceed to the flight sortation process. Those bags that fail passenger reconciliation are disposed of by the bomb squad, and those bags that clear passenger reconciliation then proceed to the flight sortation process.

The model has been programmed with the use of Standard 2 HBS equipment as defined by ICAO and IATA (2004).

The process described in d1 = Level 1 and 2 intelligent X-ray machine

d2 = Level 3 computer tomography X-ray machine.

Figure 13 is the recommended practice process, defined by Norman Shanks, and adopted by IATA for the screening of hold baggage, and is a tiered process as described above, where all hold baggage is first processed through the Level 1 machines (component d1), and 20% of the demand is processed through level 2 equipment (component d3), and 5% of the demand is processed through level 3 equipment (component d2).

The quantity of component d1 used is defined by the equation:

$$Nd1 = \frac{D}{Pd1} \quad \text{... 4}$$

The quantity of component d2 used is defined by the equation:

$$Nd2 = \frac{D \text{ X } 5\%}{Pd2} \quad \text{... 5}$$

Where:

Nd1= The number of d1 components present

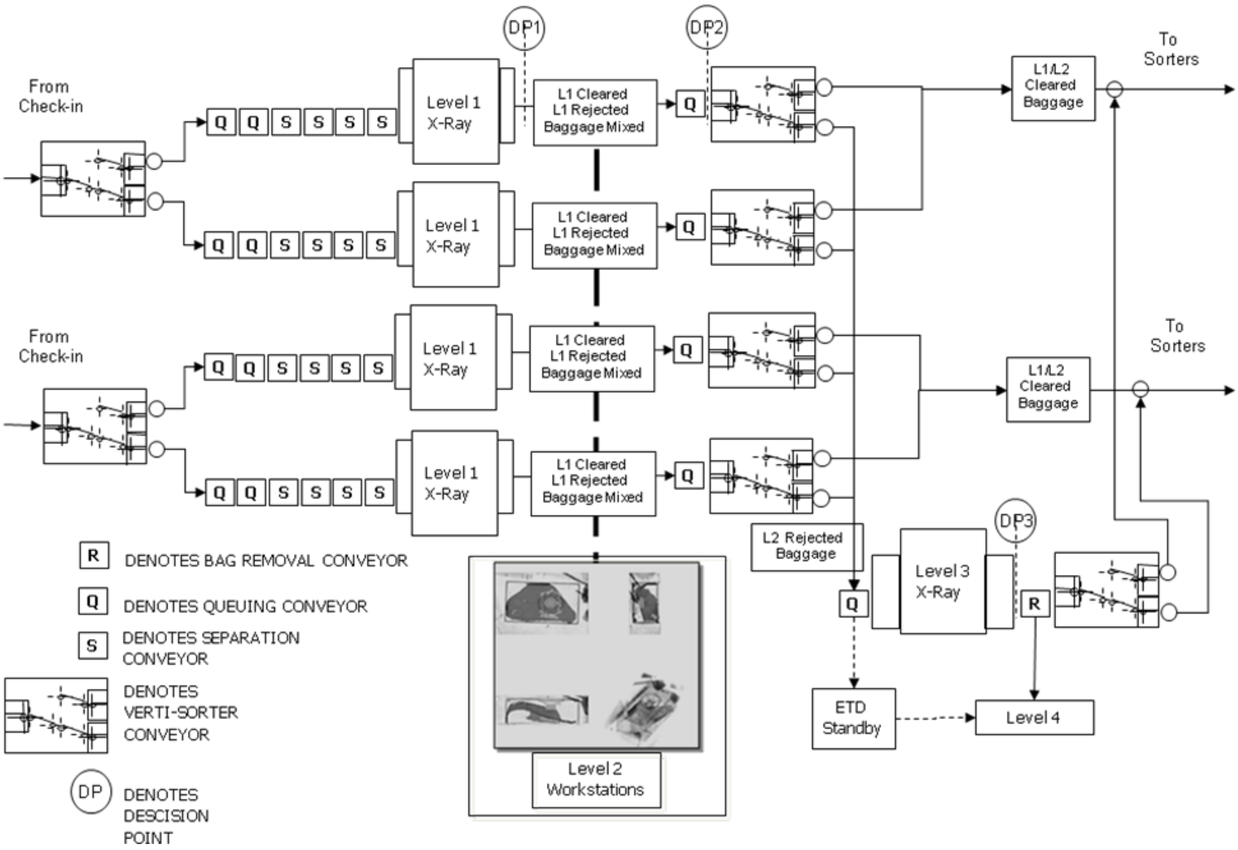
Nd2 = The number of d2 components present

D = Demand = Bags/Min.

Pd1 = Processing rate of the Level 1 & 2 Intelligent X-ray machine = 20 Bags/Min.

Pd2 = Processing rate of the Level 3 CT X-ray machine = 4 Bags/Min.

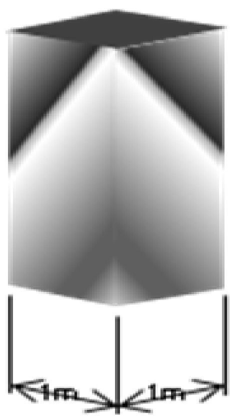
Figure 13: Standard process of hold baggage screening



Source: Norman Shanks Associates

3.3.7 Component d3 hold baggage screening level 2 workstation

Figure 14: Component d3 hold baggage screening level 2 workstation



Function: The component d3 as noted in Figure 14 defines the hold baggage screening level 2 workstation. Whilst the shape defined in Figure 14 is arguably not representative of a typical computer workstation, the plan area that it occupies is representative.

The quantity of component d3 used is defined by the equation:

$$Nd3 = \frac{D \ X \ 20\%}{Pd3} \qquad \text{... 6}$$

Where:

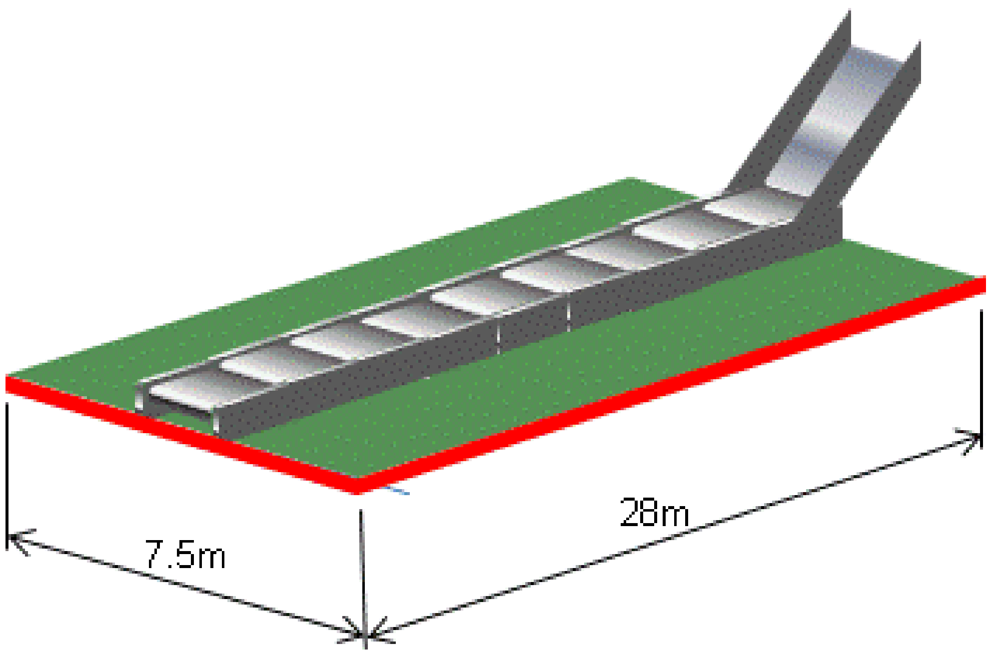
Nd3 = The number of d3 components present

D = Demand = Bags/Min.

Pd3 = Processing rate of the component d3 = 3 Bags/Min.

3.3.8 Component e1 flight lateral (1x28m)

Figure 15: Component e1 flight lateral (1x28m)



Function: The flight lateral as denoted in 3.3.8 Component e1 Flight Lateral (1x28m) seen in Figure 15, stores ATL baggage by flight number, and in some instances by flight passenger class segregation on the lateral conveyors. BHS loader staff then manually load the bags into the ULD containers. Where it is envisaged that excessively heavy baggage will be transferred from the BHS lateral to awaiting ULDs, IATA (2004) recommend the provision of heavy baggage lifting equipment at the correct locations so that the risk of off-loading injuries on staff is minimized. From a CAPEX and OPEX perspective, the component e1 excludes the provision of such manual handling aids.

The model incorporates the component e1 in the fully automatic, and the semi-automatic build BHS solutions only, where the component e1 is used for the proportion of non fully automated build, and non semi-automated build output technology. The model was programmed to incorporate any proportion of lateral build plus any proportion of fully automated build or semi-automated build. This input is set within the assembly environment worksheet (see Appendix D).

The results contained within this thesis have been calculated using a 75% proportion of lateral build (component e1) with a 25% proportion of either fully automated robotic build cell (component g1), or a semi-automated RTT build cell (component g2).

The quantity of component e1 used is defined by the equation:

$$Ne1 = \frac{D \times 75\%}{Pe1} \qquad \text{... 7}$$

Where:

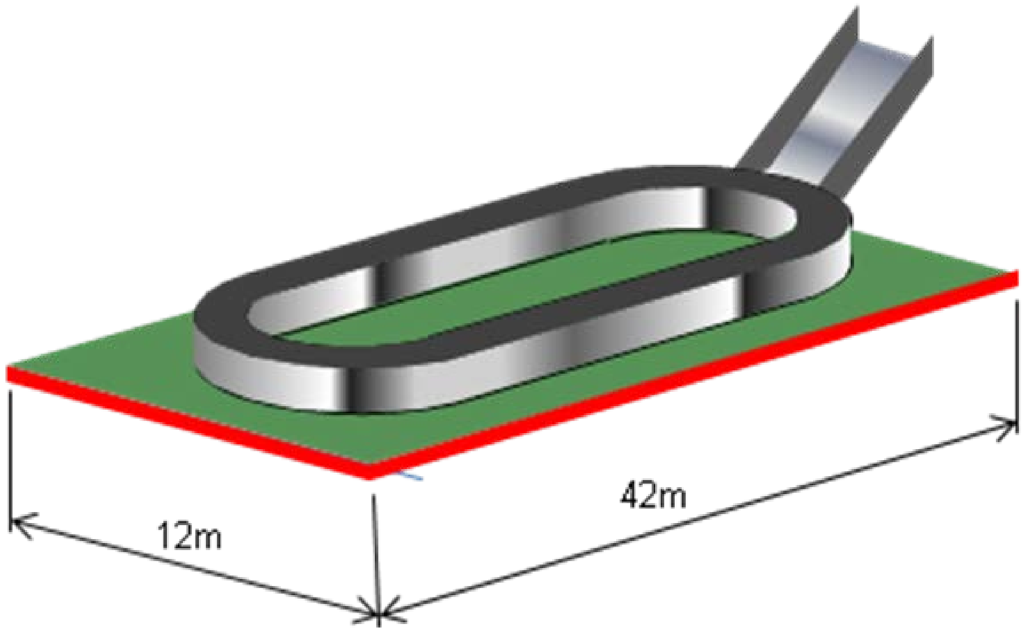
Ne1 = The number of e1 components present

D = Demand = Bags/Min.

Pe1 = Processing rate of the component e1 = 10 Bags/Min.

3.3.9 Component e3 flight racetracks (1x40m length unit)

Figure 16: Component e3 Flight Racetracks (1x40m length unit)



Function: The flight racetrack as denoted in Figure 16, stores ATL baggage by flight number, and in some instances by flight passenger class segregation. BHS loader staff then manually load the bags whilst they rotate on the racetrack and place into the ULD containers. Where it is envisaged that excessively heavy baggage will be transferred from the BHS racetrack to waiting ULDs, IATA (2004) recommend the provision of heavy baggage lifting equipment at the correct locations so that the risk of off loading injuries on staff is minimised. From a CAPEX and OPEX perspective, the component e3 excludes the provision of such manual handling aids.

The quantity of component e3 used is defined by the equation:

$$Ne3 = \frac{D \times 100\%}{Pe3} \qquad \ldots 8$$

Where:

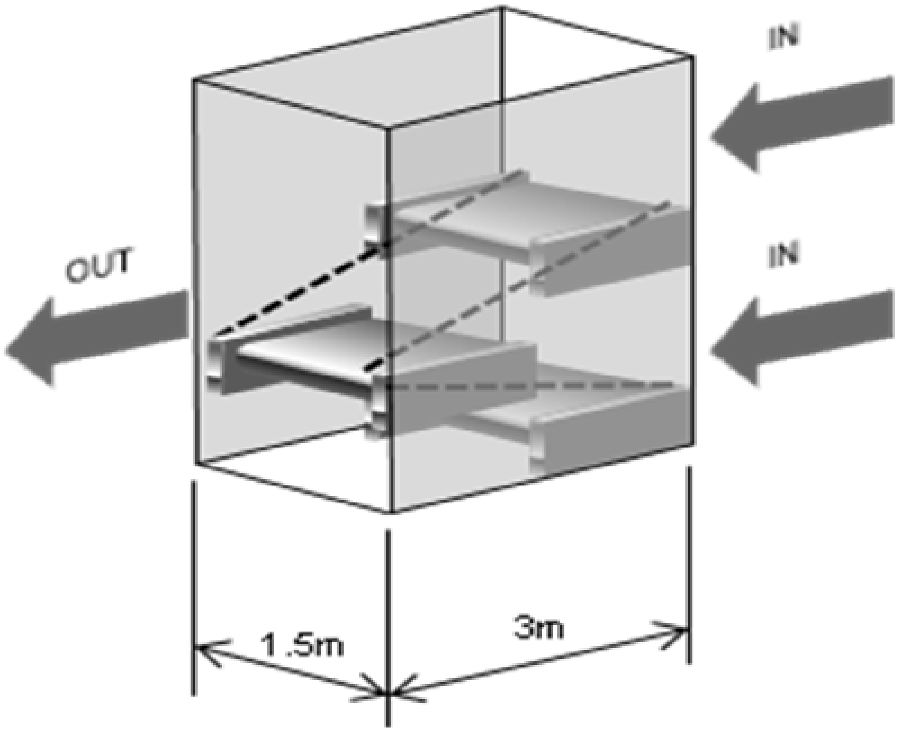
Ne3 = The number of e3 components present

D = Demand = Bags/Min

Pe3 = Processing rate of the component e3 = 10 Bags/Min.

3.3.10 Component e7 merge VSU

Figure 17: Component e7 merge VSU



Function: The verti-sortation unit (VSU) merge device is used to combine baggage flows. Baggage can be dynamically merged such that 2 bags travelling in succession on separate delivery lines can have the same output destination.

The number of component e7 (Ne7) used is defined by the rule that:

Ne7 =

IF #[40] delivery line (b1 component) is less than 2 then, # of Merge VSU (e7 components) = 0

Else the # of Merge VSU (e7 components) = # Delivery lines (component b1) - 1

Plus add..

[40] # Denotes quantity of or number of

IF # of Standard 2 Level 1 Units (component d1) is less than 2 then, # of e7 components = 0

Else the # of Merge VSU (e7 components) = # of Standard 2 Level 1 Units (component d1) – 1

Plus add..

IF # of Robotic Build Cell Units (component g1) is less than 2 then, # of e7 components = 0

Else the # of Merge VSU (e7 components) = # of Robotic Build Cell Units (component g1) – 1

Plus add..

IF # of RTT Build Cell Units (component g2) is less than 2 then, # of e7 components = 0

Else the # of Divert VSU (e7 components) = # of RTT Build Cell Units (component g2) – 1

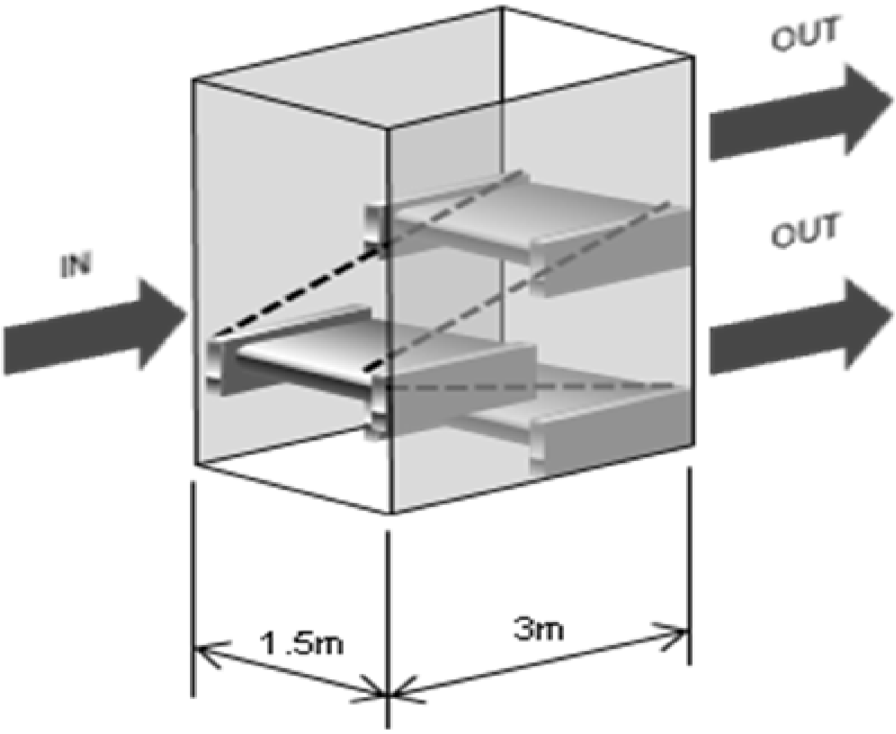
Plus add..

IF # of Flight Racetrack Units (component e3) is less than 2 then, # of e7 components = 0

Else the # of Divert VSU (e7 components) = # Flight Racetrack Units (component e3) – 1

3.3.11 Component e9 divert VSU

Figure 18: Component e9 divert VSU



Function: The vertical sortation unit (VSU) divert device is used to separate baggage flows. Baggage can be dynamically separated such that 2 bags travelling in succession on the same delivery line can be output to two separate output destinations.

The number of component e9 (Ne9) used is defined by the rule that:

Ne9 =

IF # delivery line (b1 component) is less than 2 then, # of Divert VSU (e9 components) = 0

Else the # of Divert VSU (e9 components) = #Delivery lines (component b1) - 1

Plus add..

IF # of Standard 2 Level 1 Units (component d1) is less than 2 then, # of e7 components = 0

Else the # of Divert VSU (e9 components) = # of Standard 2 Level 1 Units (component d1) – 1

Plus add..

IF # of Robotic Build Cell Units (component g1) is less than 2 then, # of e7 components = 0

Else the # of Divert VSU (e7 components) = # of Robotic Build Cell Units (component g1) – 1

Plus add..

IF # of RTT Build Cell Units (component g2) is less than 2 then, # of e7 components = 0

Else the # of Divert VSU (e7 components) = # of RTT Build Cell Units (component g2) – 1

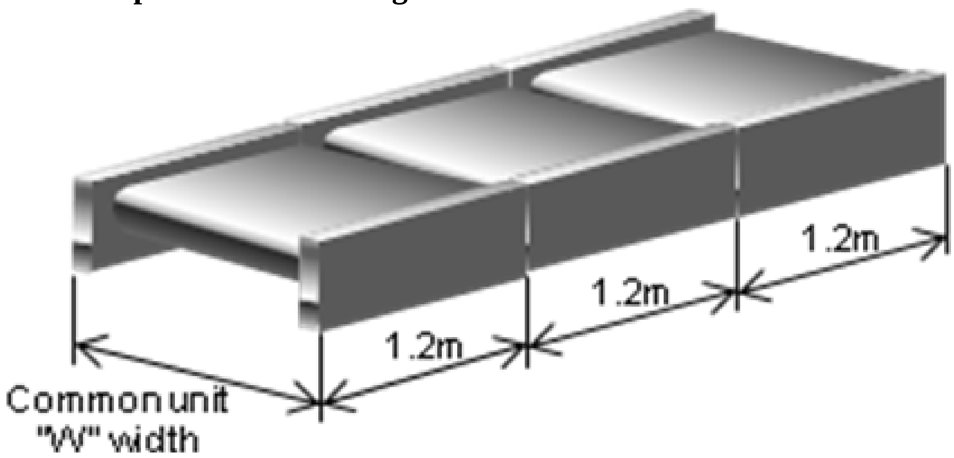
Plus add..

IF # of Flight Racetrack Units (component e3) is less than 2 then, # of e7 components = 0

Else the # of Divert VSU (e7 components) = # Flight Racetrack Units (component e3) – 1

3.3.12 Component e10 indexing

Figure 19: Component e10 indexing



Function: The component e10, indexing or queuing conveyors, are used to flatten out peak surges in bag flows within the BHS. They do this by momentarily holding back bags within a peak flow. This creates greater time gaps in flows of bag. Indexing or queuing conveyors can also be used to synchronize the flows of baggage entering HBS equipment; this ensures the efficient use of this expensive screening equipment. The component e10 conveyor can be used in many locations, and the quantity of these conveyors in a system can easily become a major contributor to the total capital, and the ongoing operating cost of the BHS. IATA (2004) denote the following locations for the use of the component e10 indexing/queuing conveyors:

- Prior to line merges or junctions;
- Prior to and during Hold Baggage Screening (HBS);
- Prior to line divert verti-sorters, ploughs, pushers;
- Prior to sorter injection points;
- Prior to flight make-up lateral components.

The quantity of component e10 used is defined by the equations:

Then for a fully automatic BHS,

$Ne10 = 5$ X [$Component\ b1 + Component\ d1 + Component\ g1$] ... 9
Where

Ne10 = Number of e10 units present

Component b1 is a Collector Belt unit

Component d1 is a Standard 2 Level 1 X-ray Unit

Component g1 is a Robotic build cell

For a semi-automatic BHS,

$Ne10 = 5$ X [$Component\ b1 + Component\ d1 + Component\ g2$] ... 10

Where

Component b1is a Collector Belt unit

Component d1 is a Standard 2 Level 1 X-ray Unit

Component g2 is a Manipulator (RTT type unit)

For a manual BHS,

$Ne10 = 5$ X [$Component\ b1 + Component\ d1 + Component\ e3$] ... 11

Where

Component b1is a Collector Belt unit

Component d1 is a Standard 2 Level 1 X-ray Unit

Component e3 is a Flight Racetracks (1x40m length unit)

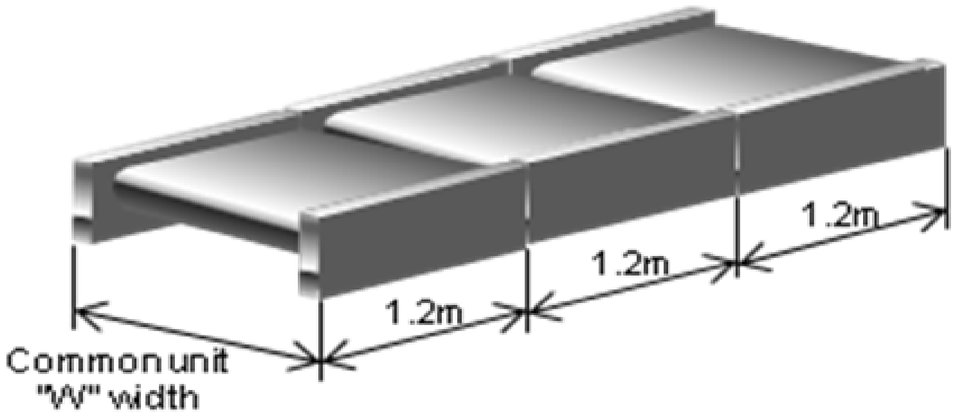
A multiplier of 5 has been used in each situation, as this is representative of the quantity of indexing, or queuing conveyors that are typically present within a baggage system, and indeed is the recommended practice (see IATA, 2004, Airport Development Reference Manual, Section U2.5.1). IATA note seven uses of the queuing conveyor, which include: (i) as a sorter injection conveyor (component e11) and (ii) as a flight make-up lateral conveyor (component e1).

Since both of the conveyors e1, and e11 are listed separately as components herein, the multiplier five has been used (e.g. 7-2=5 indexing conveyor uses per line).

It is possible that following dynamic simulation of the BHS, that the quantity of indexing / queuing conveyors could be reduced, or in some instances may need to be increased if the flow of baggage is particularly spiky.

3.3.13 Component e11 sortation induction

Figure 20: Component e11 sortation induction



Function: The Component e11 Sortation Induction unit is located at the interface between the conveyor belt BHS components, and the tilt tray sorter BHS components. The tilt tray sorter loop is a mechanism that has discrete trays with gaps between trays. It is necessary to inject the bags precisely at the correct time so that bags from the conveyor based system (component e11) do not fall between the gaps in the trays (component e12). The component e11 synchronizes the technology transfer between the belt system and the sorter system. It does this by starting and stopping the bag flows on component e11 rapidly to generate appropriate gaps between bags that are then injected onto the sorter component e12.

The induction process is designed to permit maximum throughput onto the sorter component with minimal baggage jams.

IATA (2004) note that there are three types of tilt tray sorter induction: (i) Side 30 degree; (ii) Side 45 Degree; and (iii) Overhead. The model has been designed with the overhead induction system. This system is becoming more and more commonplace.
The quantity of component e11 used is defined by the equation:

$$Ne11 = \frac{D}{Pe11} \qquad \text{... 12}$$

Where:

Ne11 = The number of e11 components present.

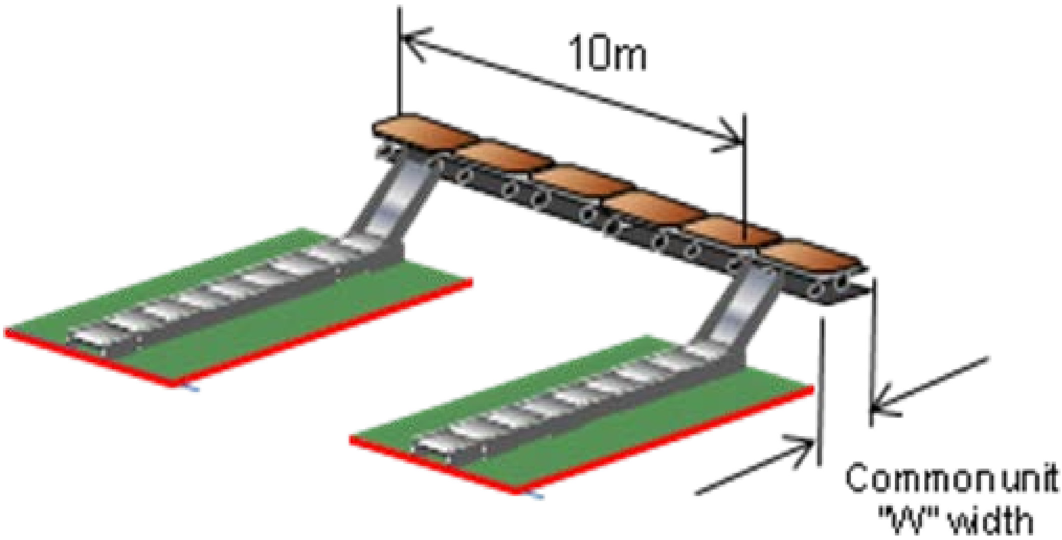
D = Demand = Bags/Min.

Pe11 = Processing rate of the component e11 = 60 Bags/Min.

The component e11 is only used where there is a sorter loop, component e12 present, this means that component e11 is present and used within fully automatic, and semi-automatic BHS only. Manual BHS do not include the sorter loop component e12.

3.3.14 Component e12 sortation loop

Figure 21: Component e12 sortation loop



Function: The sortation loop component e12 has one primary function, to route bags that have originated from either: (i) check-in, and the HBS processes, or (ii) the early bag store, as outlined in Figure 68, Figure 71, Figure 74, using the tilt tray sorter mechanism, to the correct output laterals (component e1). The tilt tray sorter mechanism comprises of wooden trays that enclose the hold baggage being transported. The wooden trays are attached to steel and aluminum wheeled carriages. These carriages run on track assemblies. The carriages are linked together to form a constant chain of carriages, and each one is encoded with a unique radio frequency or bar code identifying tag. As a passengers bag is inducted, and injected onto a tilt tray sortation loop assembly, the IATA bar code license plate number which relates to the passenger is matched up to the carriage identification tag on the tilt tray sortation loop. The BHS controls are able to track the carriages identification and tip off the passenger's baggage that relates to the flight code and destination lateral (components e1).

The quantity of component e12 used is defined by the equation:

$$Ne12 = 2 \text{ X } [(Ne1) + (Ng1)] \qquad \ldots 13$$

Where:

The multiplier 2 has been used since the sorter has, 1 off length associated within the presence of the lateral / chute components; though this is only half the total length of the sorter as it is a loop length. Hence the multiplier “2” has been used.

Ne12 = The number of e12 components present.

Ne1 = Number of component e1 (Flight Lateral (1x28m) present.

Ng1 = Number of component g1 Robotics (Grenzebach) present.

The component e12 is not used within manual sortation BHSs.

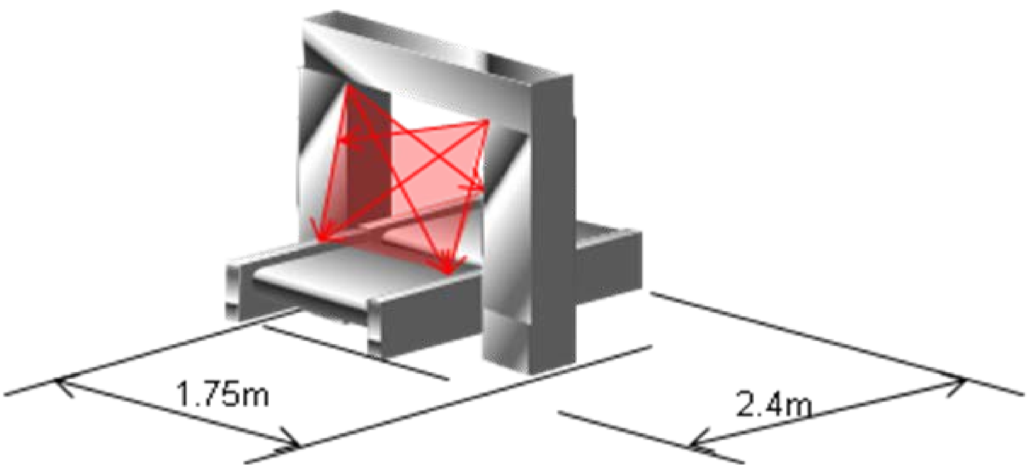
3.3.15 Component e21 power bus (1 off assembly) unit

Function: The power bus component e21 is a 3 phase power conduit and cabling system that delivers the power to all of the BHS components.

A quantity of one component e21 is required for each BHS solution.

3.3.16 Component e22 scanner array (1 unit)

Figure 22 Component e22 scanner array (1 unit)



Function: The component e22 scanner array has one primary function, and that is to dynamically scan the labels of the hold baggage that progresses through the BHS, and to verify the flight number contained within the label. The scanner array then sends that information to the BHS control system where it then uses this information to track the baggage in real time to enable the BHS control system to route the baggage to subsequent correct routes. There are two types of scanner array, the bar code reader array and the radio frequency tag reader array. Both technologies are in operation at airports across the world, but the bar code reader technology is by far the more commonplace, albeit it is less effective and reliable than the alternative radio frequency option. The larger more common bar code reader scanner array unit, Figure 22, has been defined within the model.

Normally scanner arrays are located upstream of the Component e11 Sortation Induction which permits the sorter loop then to route the departing bags to the allocated flight lateral (Component e1), robotic cell (component g1) or RTT device (component g2).

The quantity of component e22 used is defined by the equation:

$$\textit{The number of e22 components present} = \frac{D}{Pe22} \qquad \text{... 14}$$

Where:

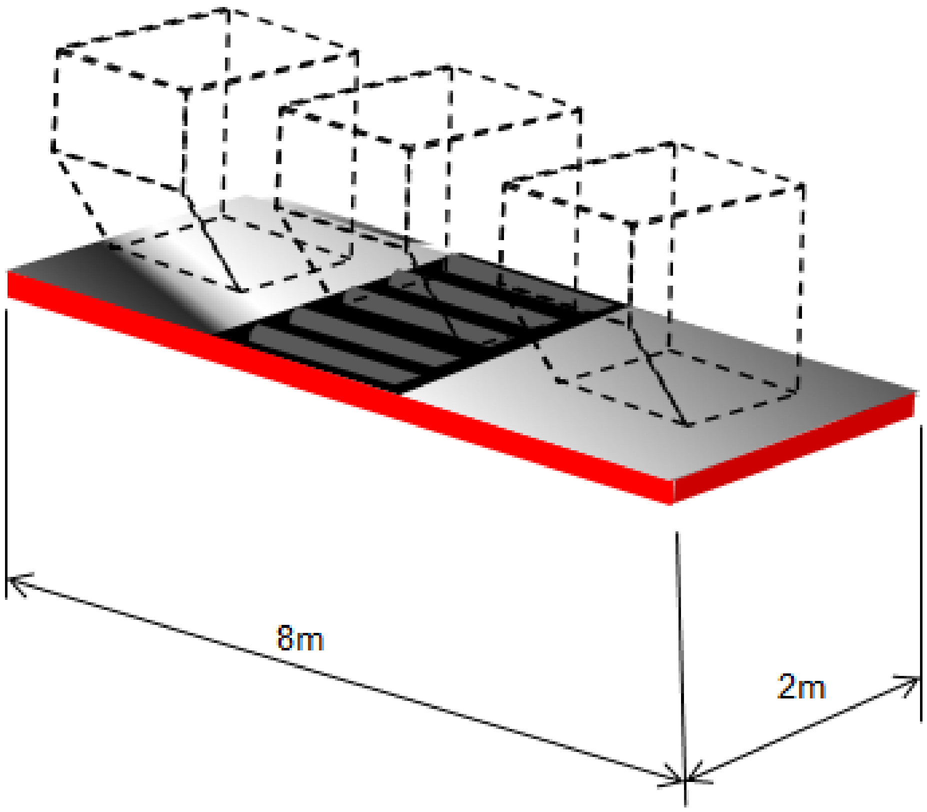
D = Demand = Bags/Min

Pe22 = Processing rate of the component e22 = 50 Bags/Min.

3.3.17 Component f2 ULD powered rollerbed

Figure 23: Component f2 ULD powered rollerbed

(2x2m rollerbed plus 1m walkway x 2 Plus 2m dock x 2)



Function: The component f2 is used to store, and move empty and full ULD equipment. There are two types of this equipment powered and unpowered. The model references the powered version of component f2. It should be noted that the volumetric definition of component f2 incorporates three ULDs simultaneously.

The quantity of component f2 used is defined by the equations:

Fully Automatic BHS: ... 15

$$Nf2 = \frac{[(13 \text{ X } Ng1) + (10 \text{ X } NSH) + (20 \text{ X } NLH)]}{3}$$

Where

Nf2 = The number of component f2 present.

Ng1 = The number of component g1 present

Ng2 = The number of component g2 present

NSH = The number of flights Short Haul/hour

NLH = The number of flights Long Haul/hour

And,

Where for every Robot Component g1 there is…

3 ULDs spaces and

5 Lead in spaces and

5 exit spaces

Total 13 ULD/Robot

Plus storage needed:

Code C 10ULDs/Flight

Code F 20ULDs/Flight

Semi-automatic BHS: ... 16

$$Nf2 = \frac{[(13 \text{ X } Ng2) + (10 \text{ X } NSH) + (20 \text{ X } NLH)]}{3}$$

Where

Where for every RTT Component g2 there is…

3 ULDs spaces and

5 Lead in spaces and

5 exit spaces

Total 13ULD/RTT

Plus storage needed:

Code C 10ULDs/Flight

Code F 20ULDs/Flight

Manual BHS: ... 17

$$Nf2 = \frac{[(10 \, X \, NSH) + (20 \, X \, NLH)]}{3}$$

Where

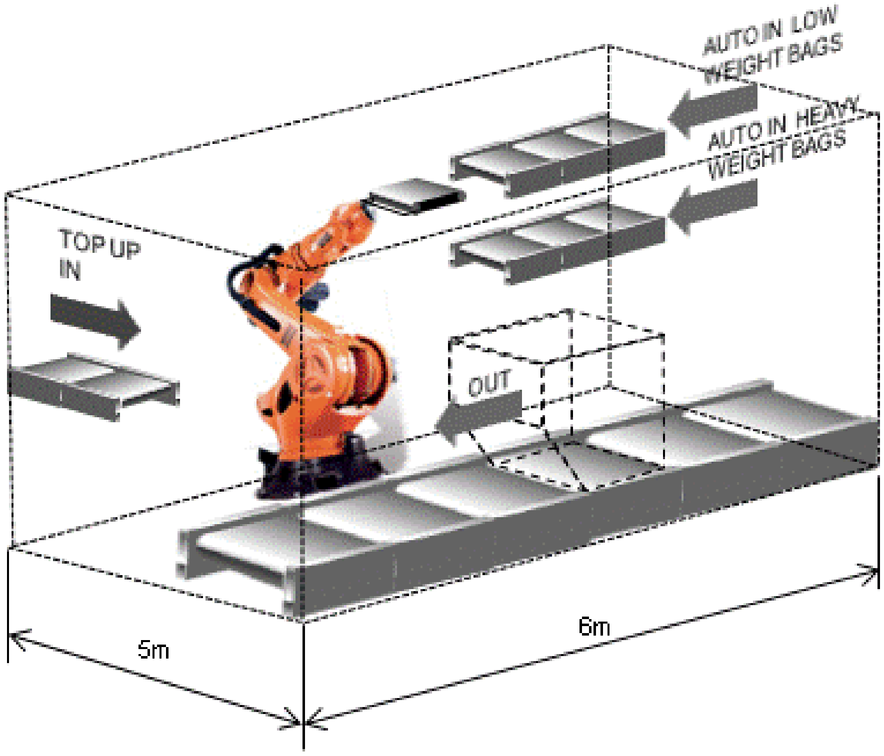
Where storage needed:

Code C 10ULDs/Flight

Code F 20ULDs/Flight

3.3.18 Component g1 robotic build cell

Figure 24: Component g1 robotic build cell



Function: The robotic build cell has one primary function, and that is to build departing bags into departing ULDs. It does this by receiving baggage from its inputs, and then: (i) determines what space remains within the ULD that is within the build cell environment, and (ii) to automatically, without human intervention, place bags correctly into the available spaces within the ULD. The first item is achieved using laser scanners which measure, and with a build cell computer, evaluate the available space within a ULD, and then compute the most effective zone to place bags of varying sizes. The robotic build cell computer measures the size, and weight of every bag that enters to the build cell environment, and calculates to the optimum build / bag placements within the ULD. It also has an algorithm that ensures that the heavier bags are placed at the bottom of the ULDs to ensure ULD transportation stability.

The robotic build cell component g1 is present only in the fully automatic BHS solution.

The results contained within this thesis have been calculated using a 75% proportion of lateral build (component e1) with a 25% proportion of the fully automated robotic build cell (component g1).

The quantity of component g1 used is defined by the equation:

$$Ng1 = \frac{D \times 25\%}{Pg1} \qquad \text{... 18}$$

Where:

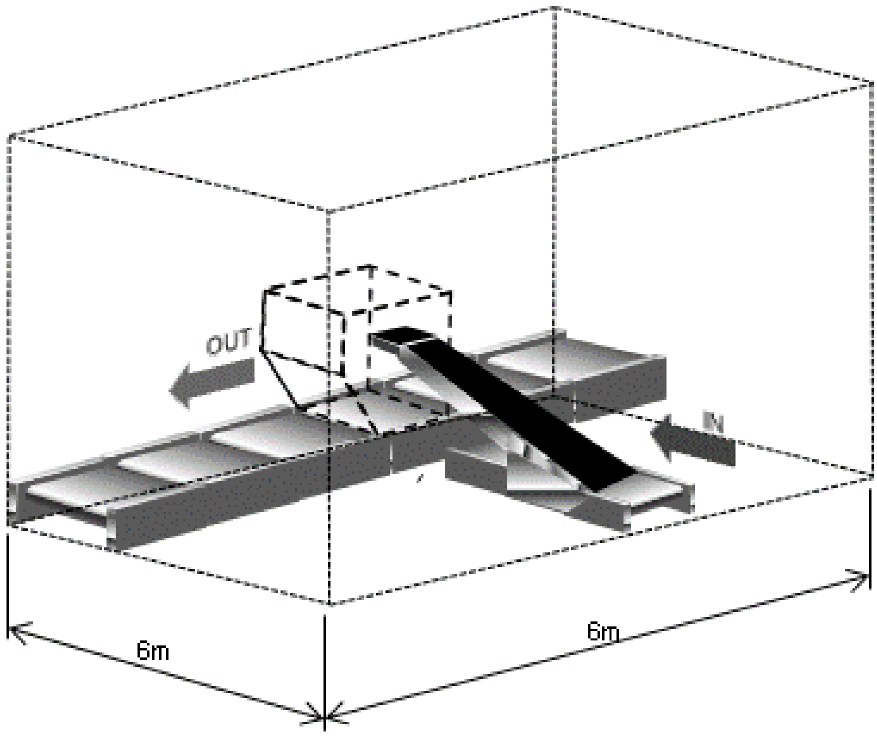
Ng1 = The number of g1 components present.

D = Demand = Bags/Min.

Pg1 = Processing rate of the component g1 = 4 Bags/Min.

3.3.19 Component g2 RTT (Teleair) semi-automated build cell

Figure 25: Component g2 RTT (Teleair) semi-automated build cell



Function: The RTT build cell has one primary function, and that is to build departing bags into departing ULDs. It does this by receiving baggage from its input conveyor, and then an operator controls the RTT system themselves which points, directs, and extends the RTT loading conveyor. There is no computer algorithm that will calculate the optimum build into a ULD, instead the RTT operator must manually determine the optimum placement of the bags into the ULD. It should be noted that whilst the processing rate of the RTT is 6 bags / minute / unit which is greater than that of the robotic build cell component g1 which is 4 bags / minute / unit, there remains the question with the RTT component with regards to its ability to consistently perform at this higher rate. The RTT rate is governed by the capacity of the RTT manual operator, and arguably the continued enthusiasm of the manual operator to work at this high rate for prolonged periods. The robotic build cell will not take tea and comfort breaks that an operator will typically take. The RTT operator work rate will decline as the operator becomes naturally tired towards the end of a shift.

The RTT build cell component g2 is present only in the semi-automatic BHS solution. The results contained within this thesis have been calculated using a 75% proportion of lateral build (component e1) with a 25% proportion of the semi-automated RTT build cell (component g2).

The quantity of component g2 used is defined by the equation:

$$Ng2 = \frac{D \times 25\%}{Pg2} \quad \text{... 19}$$

Where:

Ng2 = The number of g2 components present.

D = Demand = Bags/Min.

Pg2 = Processing rate of the component g2 = 6 Bags/Min.

3.3.20 Component h1 power conditioner

Function: The power condition component h1 is required to maintain a constant (within a prescribed tolerance: power and frequency) power supply to the BHS equipment, removing any power spikes that might be occur from the power incomer (component h2) that originate from a local transformer connected to the national grid. A quantity of one component h1 is required for each BHS solution.

3.3.21 Component h2 power incomer (1 off per drive)

Function: The power incomer component h2 connects the local power transformer from the national grid to the power conditioner component h1. A quantity of one component h2 is required for each BHS solution.

3.3.22 Component h3 motor controllers (1 off)

Function: The motor controller Component h3 distributes the 3 phase power from the power conditioner, component h1, to each of the BHS motor drives located within the baggage hall. A quantity of one component h3 is required for each BHS solution.

3.3.23 Component h4 programmable controller computer

Function: The Programmable Controller Computer, otherwise known as the overview level PLC computer, manages the multiple detailed level motor Programmable Controller Module components h5. The primary function of the component h4 is to know where every bag is, in real time, within the BHS, and to control the flow of baggage, by giving instructions to the multiple components h5, to stop or start each conveyor within BHS. A quantity of one component h4 is required for each BHS solution.

3.3.24 Component h5 programmable controller module

Function: The Programmable Controller Module component h5, otherwise known as detailed level programmable logic controllers reside on each conveyor unit within the BHS; the component h5 receives start stop commands from the overview level PLC component h4, and data from adjoining detailed level programmable controller modules. With this information, and information that it too sends, it directly controls the stop start function of the conveyor that it occupies.

A quantity of one component h5 is required for each BHS conveyor drive present within the BHS. The total quantity of drives present is calculated by the model.

3.3.25 Component h6 programmable controller software

Function: To enable the components h4, h5, and h6 to operate, they require programmed software code. The component h6 is that software code. A quantity of one component h6 is required for each BHS solution.

3.3.26 Component h7 sort allocation computer

Function: The sort allocation computer (SAC), component h7 is the computer system that allows the baggage handlers, and the airlines to allocate airline flight numbers and flight class segregations to output build components such as the laterals (component e1), racetracks (component e4), robots (component g1), and RTT devices (component g2). The SAC interfaces with the Programmable Controller Computer, Component h4 to ensure that bags are sent to the correct output flight. A quantity of one component h7 is required for each BHS solution.

3.3.27 Component h8 control system computer and display

Function: The component h8 computer, and display is required to process the graphical outputs that the BHS operators and the airlines and handlers shall view and utilize. A nominal quantity of 10 component h7s are required for each BHS solution.

3.3.28 Component h9 safety equipment (per drive)

Function: Each conveyor needs to be fitted with safety equipment that will stop the conveyor in the event of an emergency (e.g. hand entrapment). The component h9 is fitted to each conveyor within the BHS and usually contains power isolation switches and circuit breakers and safety circuit cabling.

A quantity of one component h9 is required for each BHS conveyor drive present within the BHS. The total quantity of drives present is calculated by the model.

3.3.29 Component h10 network (per installation)

Function: The component h10 is the backbone network which enables all of the computer and programmable logic controller devices to communicate system control and operation data upon. A quantity of one component h10 is required for each BHS solution.

3.3.30 Component h11 SCADA system (base hardware / software)

Function: The SCADA component h11 is a computer, and bespoke software system which enables the BHS computer controls to (i) provide a user interface to the BHS operators, and (ii) to interface with the building management systems (particularly the fire systems management and resultant BHS route control). A quantity of one component h11 is required for each BHS solution.

3.3.31 Component i1 handling agent manual loader (lateral/racetrack/chute)

Function: The handling agent component / resource i1 removes the departing baggage from either: (i) the flight laterals (component e1), or (ii) the racetracks (component e3), and loads (builds) the bags into the adjacent awaiting ULDS. The handling agent is also used at the base of the Chute devices (IATA 2004), though these units have not been referenced within the model as these devices are gradually being phased out of operations due to negative manual handling issues (hand entrapment and impact injuries to handling agents).

The quantity of component i1 used varies according to whether the system is a fully automatic, semi-automatic or manual BHS. The results contained within this thesis have been calculated using a 75% proportion of lateral build (component e1) with a 25% proportion of the fully automated Robotic build cell (component g1).

The results contained within this thesis have been calculated using a 75% proportion of lateral build (component e1) with a 25% proportion of the semi-automated RTT build cell (component g2).

For fully and semi-automated build BHSs the quantity of component / resource i1 used in each BHS option is defined by the equation:

$$Ni1 = \frac{D \times 75\%}{Pi1} \qquad \text{... 20}$$

For manual build BHSs the quantity of component / resource i1 used in each BHS option is defined by the equation:

$$Ni1 = \frac{D \times 100\%}{Pi1} \qquad \text{... 21}$$

Where:

Ni1 = The number of i1 components present.

D = Demand = Bags/Min.

Pil = Processing rate of the component i1, the manual handling baggage build rate of single manual handling agent operative is 2 bags/minute/operator.

3.3.32 Component i2 manual loader (robotics support & top up)

Function: There are occasions when the robotic build cells require an operator to intervene within the normal flight build sequence. The operator is normally needed to carry out two activities: (i) when a bag has behaved in an unpredicted manner (fallen off of the robotic actuator arm) which the robotic build cells logic algorithm, and mechanics cannot resolve, or (ii) the last few bags within a full ULD need to be loaded into the ULD manually by an operator. The component i2 is only used when a robotic build cell(s) is referenced within the model BHS solution.

The results contained within this thesis have been calculated using a 75% proportion of lateral build (component e1) with a 25% proportion of the fully automated Robotic build cell (component g1).

The quantity of component i2 used is defined by the equation:

$$Ni2\ (robotic) = Ng1 \text{ X } 50\% \qquad \text{... 22}$$

Where:

Ni1 (robotic) = The number of i2 staff components present supervising the robots.

50% factor relates to the issue that every two robotic build cells (component g1) require one operator component i2.

3.3.33 Component i3 manual loader (RTT)

Function: The manual loader (RTT) component / resource i3 operates, and controls the RTT component g2. For every RTT component g2 there is a corresponding manual loader (RTT) resource needed.

The results contained within this thesis have been calculated using a 75% proportion of lateral build (component e1) with a 25% proportion of the semi-automated RTT build cell (component g2).

The quantity of RTT staff component i3 used is defined by the equation:

$$Ni3(RTT) = Ng2 \qquad \text{... 23}$$

Where

Ni3(RTT) = The number of component i3 manual loaders present.

Ng2 = The number of component g2 present.

3.3.34 Component j1: steelwork platform

Function: The steelwork platform is designed to hold and support specific BHS equipment, and permit this equipment to have maintenance access.

The quantity of component j1 used is defined by the equation: ... 24

$$Nj1 = [Na1 \text{ X } 1.2] + [Nb1 \text{ X } 20] + [Nb4 \text{ X } 2.5] + [Nc1 \text{ X } 1.2] + [Nd1 \text{ X } 5]$$
$$+ [Nd2 \text{ X } 8] + [Ne1 \text{ X } 30] + [Ne7 \text{ X } 2.5] + [Ne9 \text{ X } 2.5] + [Ne10 \text{ X } 1.2]$$
$$+ [Ne11 \text{ X } 1.2] + [Ne12 \text{ X } 1] + [Nf2 \text{ X } 8] + [Ng1 \text{ X } 6]$$

Where

Nj1 = The area of component j1present.

Na1 = Number of Component a1 Check-in present.

Nb1 = Number of Component b1 Collector Belt present.

Nb4 = Number of Component b4 Powered Belt Curve present.

Nc1 = Number of Component c1 Conveyor Lane Q conveyors present.

Nd1 = Number of Component d1 Standard 2 Level 1 Unit present.

Nd2 = Number of Component d2 Standard 2 Level 3 Unit present.

Ne1 =Number of Component e1 Flight Lateral present.

Ne7 = Number of Component e7 Flight Lateral present.

Ne9 = Number of Component e9 Divert VSU present.

Ne10 = Number of Component e10 Indexing present.

Ne11 = Number of Component e11 Sortation induct present.

Ne12 = Number of Component e12 Sortation loop present.

Nf2 = Number of Component f2 ULD Powered Rollerbed present.

Ng1 = Number of Component g1 Robotics (Grenzebach) present.

3.3.35 Component j3 stairs

Function: Most BHSs are designed on two or more levels, with the upper level(s) of the BHSs usually being supported by steel mezzanine(s). It is for this reason that an allowance has been made for the provision of steelwork stairs that will be needed to access the BHS equipment on the multiple levels.

The quantity of component j3 used is defined by the equation: ... 25

$$Nj3 = \frac{\sum drives}{30}$$

where

Nj3 = The number of j3 stair components present.

$\sum$ drives = Total number of powered conveyor drives present within the BHS.

3.3.36 Component k1 fire door

Function: The fire door component k1 has two functions, to provide fire rated seal, and to provide a security seal between the airports landside environment, and the airports airside environment. The fire door component is fitted on each delivery line component b1 that is present within the BHS.

The quantity of component k1 used is defined by the equation: ... 26

$$Nk1 = Nb1$$

where

Nk1 = The number of k1 Fire Doors present.

Nb1 = The number of delivery lines component b1 present.

3.4 Chapter summary

This Chapter explained the questions that were raised to aid the development of the model. The answers to these questions, that are given, have permitted the electro mechanical components referenced within the model to be defined. The process maps, the logic that are defined within the three types of BHS types that can be built within the model is explained. The following Chapter 4 outlines the method and operating philosophies that the pull and the push BHSs need to adopt. Chapter 4 also analyses the ULD availability and storage requirements which must be accurately predicted to enable a cost effective BHS to be specified. This ULD storage analysis has been incorporated into the equation that defines the quantity ULDs (see section 3.3.17 component f2) that a BHS must provide to enable it to function correctly.

4. MODEL DEVELOPMENT

4.1 Overview

This section provides an explanation of the operating philosophies that distinguish the three baggage handling operating build models. The actual baggage demand profile characteristics witnessed within a baggage system are explained that are referenced within the model. The equation 27 is defined which has been used to predict the flow of baggage within a theoretical baggage system environment of the model, for any proposed baggage demand scenario. This baggage input profile per flight can also permit the size of the Early Bag Store to be determined, as the number of bags that need to be stored before the flight(s) has actually opened can be calculated.

4.2 BHS operating philosophies

There are three operating baggage build philosophies which are known to be capable of processing passenger hold baggage through BHSs, these are:

(i) Historic conventional "manual" build;

Summarized characteristics:

Flight lateral / chute opens STD[41] - 180 minutes for long haul, and STD - 45 minutes to STD - 90 minutes for short haul. Bags are loaded into ULDs or baggage carts by staff manually.

(ii) Compressed conventional build

Summarized characteristics:

[41] STD abbreviation, Standard Time of Departure: point in time when aircraft departs the stand.

Flight lateral / chute opens at STD - 90 minutes for long haul. Effective ULD coordination is required. Bags are loaded into ULDs or baggage carts by staff manually.

(iii) Fully or semi-automated build

Summarized characteristics:

Build cell concept used: cell opens before STD - 90 minutes, e.g. STD – 90 minutes to STD – 300 minutes. Bags are loaded into ULDs or baggage carts by machines efficiently, e.g. robotics or man machine interface device used. Effective ULD coordination is also required.

Operating philosophy (ii) has not been used to process actual passenger baggage. Successful trials of this method were completed in March 2011, within a major UK airport BHS, using "test baggage"[42]. The trial proved that this method is practical, and highly efficient when in use.

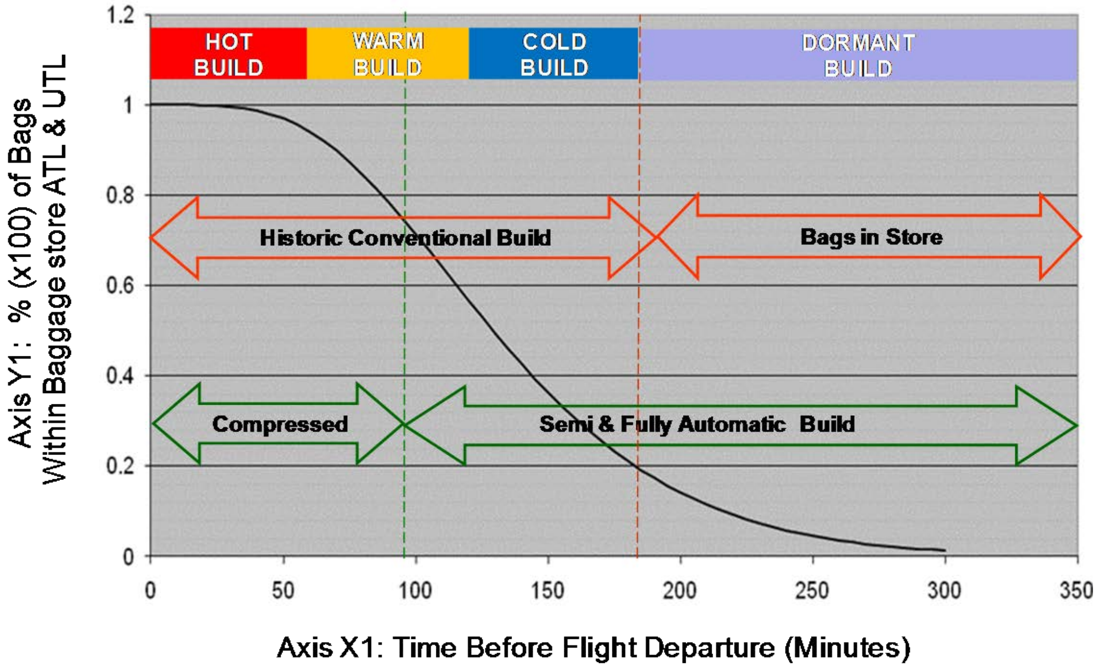
The historic conventional build philosophy is as the names suggests the de facto process adopted by most of the world airports processing baggage within category A, B, and C BHSs, as recommended by IATA, (2004).

The automated build philosophy, using robotic build, has been in live trial operation at Amsterdam airport, since 2002. Subsequently, six robotic automatic build cells have been operation since March 2011, as noted by Samola (2008).

These operating philosophies dictate the BHS components selected to process the hold baggage, and have been embedded into the model BHS assembly logic.

[42] Test baggage: baggage which weighs and is dimensionally representative of typical passenger baggage but is not real passenger baggage.

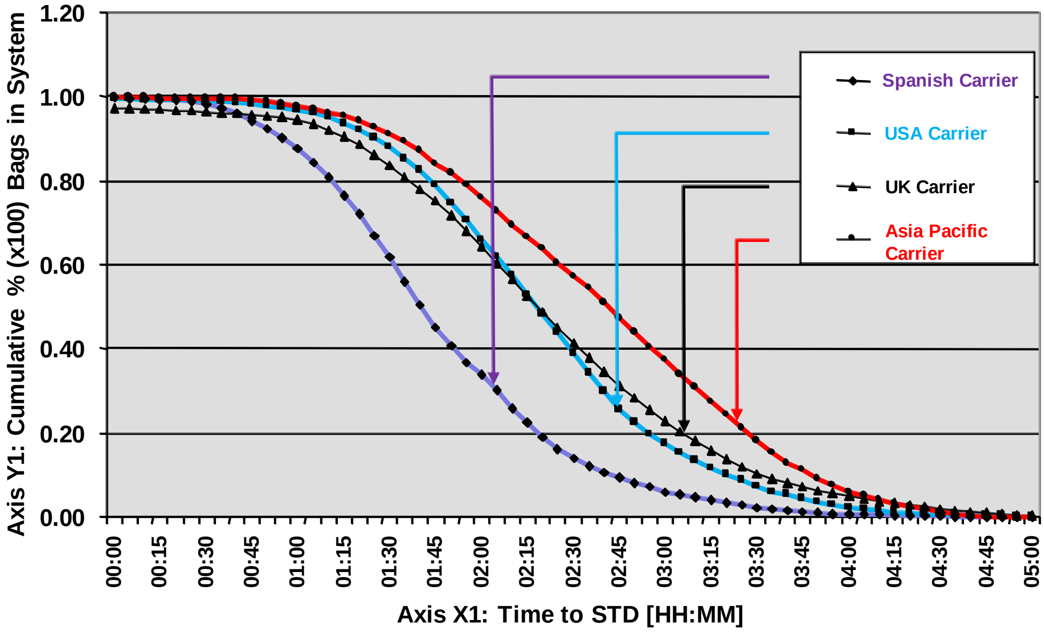
Figure 26: Bag store inventory and flight build types



4.3 Predicting baggage flow

Actual bag throughput data obtained during the research phase was used to develop the model Gamma equation (.. 27). Figure 27 shows the actual cumulative flow of baggage present within a baggage system for four typical flights plotted against the flights STD. Actual baggage profiles can be theoretically replicated (see Figure 26) using the Gamma distribution function. It is clear that actual data denoted in Figure 27 and that of the profile data calculated using the Gamma equation (see Figure 26) are very similar. It is for this reason that the Gamma function was referenced within the model.

Figure 27: Baggage input profile - actual airport bag flow data



The equation for the Gamma λ distribution (Source: Microsoft Excel Gamma Function Explanation) is:

$$f(x;\alpha,\beta) = \frac{1}{\beta^{\alpha}\,\Gamma(\alpha)}\, x^{\alpha-1}\, e^{-\frac{N}{\beta}} \qquad \ldots 27$$

where standard Gamma distribution series is:

$$\boldsymbol{\Gamma(\alpha)} \qquad \ldots 28$$

The Gamma function variables[43], Alpha (α) is set at a value of 5.5, and Beta (β) is set at a value of 25 within the model. It should be noted that the Gamma function variables α, and β can be adjusted to best match any airports specific bag store profile characteristics.

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[43] Gamma function variables Alpha (α) = 5.5 and Beta (β) = 25 were used as they best replicate the actual BHS flow data as witnessed in Figure 27.

where

X = The STD variable

(α) Alpha = 5.5 (airport/airline specific)

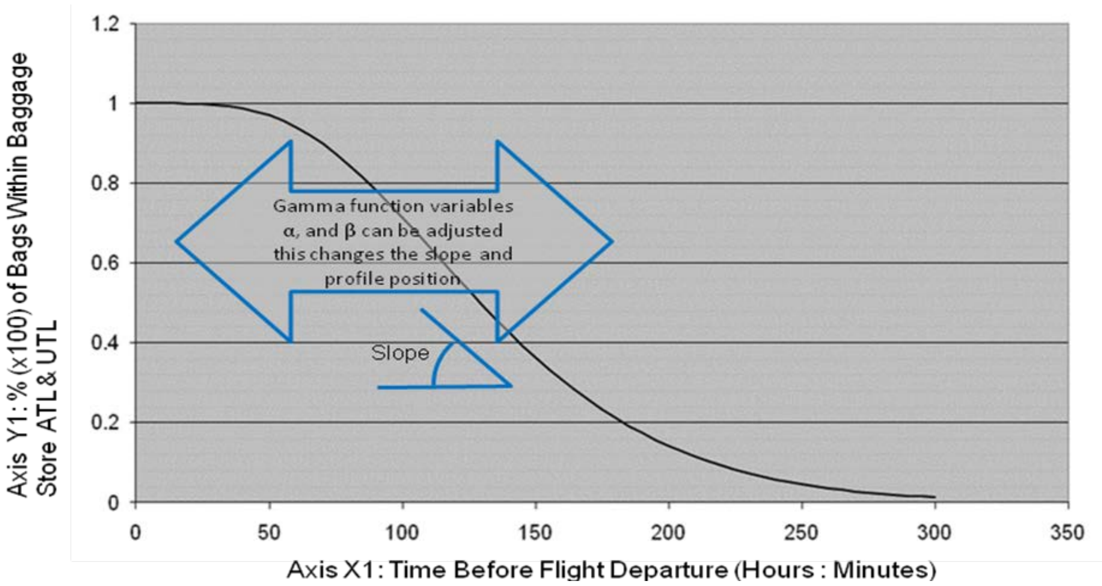
(β) Beta = 25 (airport/airline specific)

$f(X; \alpha, \beta)$ = Gamma distribution output at X

Gamma Resolution = 5 minute intervals

If one changes the variables α, and β individually, the gradient, and the position of the baggage profile can be adjusted relative to the STD position. Moving the Gamma profile toward STD would generally represent the profile witnessed at airports processing more peaky traffic.

Figure 28: Baggage input profile – theoretical Gamma function airport bag flow data



The model can generate the flow distribution of baggage present within a BHS for any quantity of flights per hour, and any type of flights (long and/or short haul), using the input variable worksheet dashboard (Appendix B). Each flight entered follows the Gamma profile, and this information is then referenced within the sample flight schedule that is shown in Appendix F (peaking factor worksheet). The peaking factor worksheet calculates the 5 minute interval peaking factor that can be present with certain Gamma profiles. The α (5.5), and β (25) constant values set in the Gamma equation, do not produce a noticeable peaking factor. Different α, and β values could create a peaking factor in excessive of 100%; in this situation if a peak flow rate per flight did exist in any of the 5 minute intervals measured over a 1 hour period then the resultant peaking factor would be entered into the "Input Variables" worksheet dashboard (Appendix B), this in turn would increase the baggage flow rate demand placed on the BHS.

The model is not a dynamic model, that is the quantity of equipment or resources calculated to be required is directly determined by the static throughput rate of the pieces of equipment or resource that are pulled out of the equipment database, and assembled according to the process rules defined within Chapter 3. That stated, it can been seen from Appendix F, that with the selected bag departure profiles used per long haul, and per short haul flight, assembled into according flight schedules, that the resultant baggage flow rate, at any time interval, does not create a demand baggage flow rate, measured over an hour period, that will exceed 100%; therefore the peaking factor used within the model input has been set at 0% accordingly to show that no excessive peaks exist.

In practice all BHSs are very dynamic, and BHSs respond to not only hourly bag flows but minute by minute peak flows. The "peak" bag flow rate can create mini surges of bags through the BHS, these surges are absorbed in the queuing (indexing component e10) conveyors that have been specified within Chapter 3. It is therefore also reasonable to maintain that the peaking factor used within the model is set at 0% additional bag flow rate, as any peak surges would be absorbed by the equipment specified.

4.4 ULD storage requirements

Operationally all BHSs require ULDs[44] to be stored locally at the airport. The quantity of ULDs that are operationally required to be stored is dependent upon: (i) how many airlines are present, and what ULD sharing is permitted; (ii) BHS throughput; (iii) arriving baggage/ULD input profile, and (iv) the quantity of ULDs that maybe required by the airline(s).

Chapter 3, section 3.3.17 provides the equation that defines how many ULD storage spaces are required for the three types of BHSs. The equations for the Fully Automatic BHSs (..15), the equation for the semi-automatic BHSs (...16), and the equation for the manual BHS (..17) all include two constants with the numerical value of 10 ULDs needed per short haul flight, and 20 ULDs needed per long haul flight. This section explains how those operational constants were determined.

Handling agents and self-handling airlines have difficulty in predicting the quantity of ULDs that must be stored at the airport in preparation for servicing the ULD needs of outbound flights.

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[44] Unit load device (ULDs): These are aluminium containers of various fixed sizes, as defined by the International Air Transport Association (IATA, 2004) which can store passenger hold baggage within the baggage hall, the apron or on capable aircraft.

An equation that encompasses the integral of the regular Gamma function is proposed to calculate the percentage of bags that can be built into outbound ULDs by reusing ULDs that have arrived on the same inbound aircraft. By knowing the quantity of ULDs that can be built using ULDs from this source, one can then determine the remaining quantity of ULDs that need to be stored locally, and hence the size of the ULD stores (component f2) that are needed.

The criticality of the in-bound aircraft "brakes on time"[45] relative to the departure time of the outbound aircraft, which are stated as an input in the input variables dashboard (Appendix B), and the effect this has on: (i) the quantity of available ULDs that can be built, and; (ii) the quantity of ULDs that need to be stored on the airport complex is explained.

The quantity of bags that can be built, and moreover the quantity of ULDs that need to be stored are tabularised specifically for the Airbus 318, Airbus 320, Airbus 340, Airbus 380, Boeing 737, Boeing 757, Boeing 777, Boeing 747, and Boeing 787 aircraft. The results are shown for varied "brakes on time" of the inbound aircraft using a common standard time of departure (STD) timescale set by the outbound aircraft that is serviced.

There is no previously published method that will calculate the percentage of bags that can be built into ULDs or baggage carts, when it is understood that an inbound aircraft provides the ULDs for a subsequent outbound flight departure, and where baggage carts are readily available. There is a method documented by IATA (2008)

[45] Brakes on Time: This is the point in time when an arriving aircraft has taxied onto the aircraft stand, then stopped, and the brakes of the aircraft have been applied.

that will calculate the necessary positioning of ULDs across an operational flight network. The method proposed herein defines the quantity of ULDs that should be pre-stored at the airport by airlines, and handling agents by predicting the demand of ULDS. This demand is governed by the real time position of the baggage that is to be built into the ULDs.

The flow of baggage into a baggage system is not physically linked to the availability of ULDs or baggage carts on the airport. They are however constrained by a common real time element though; the inbound and outbound flight schedule. It is critical to understand the baggage profile within a baggage system, and to be capable of modelling this relative to this schedule or to a common time line. The analysis that follows uses a common time line which allows the baggage of an outbound flight, within the baggage system, to be assessed relative to the position of the inbound flight ULDs.

4.4.1 Factors that affect build

There are two factors that determine when it is possible to build the baggage for containerised flights and non-containerised flights These are: (a) the availability of ULDs for predominantly code D (E.G. Boeing 757), code E (E.G Boeing 747), and code F (E.G. Airbus 380) aircraft, and the availability of baggage carts for loose loaded baggage with Code A, B, and C (E.G. Boeing 737) aircraft; and (b) the availability of ATL baggage within the baggage system that can be directed to ULDs or carts.

4.4.1.1 Availability of ULDs

Code A, B, and C aircraft generally do not carry baggage in any form of ULD. Instead baggage is transported loosely within the hold of the aircraft. The baggage from these aircraft are loaded, and unloaded from airport-based baggage carts; the baggage carts are not loaded onto the aircraft and always reside at the originating airport. Code D, E, and F aircraft carry baggage in the hold of aircraft within ULD containers.

ULDs are usually located at:

(i) the hold of the aircraft;

(ii) head of stand ULD temporary holding areas;

(iii) the baggage hall with baggage being loaded;

(iv) the baggage hall with baggage being unloaded; and

(v) airport based ULD stores.

4.4.1.2 Quantity of ATL bags

The availability of ATL baggage which can be loaded into ULDs is dependent on the flow of baggage from check-in, and the flow of transfer baggage from interconnecting transfer flights which the airlines have allocated the ATL status. These flows often then merge in the baggage system giving a combined flow through hold baggage screening, early baggage storage and ultimately the flight sortation processes.

4.4.1.3 Confirm available ATL bags for build.

The total number of bags on the flight that are to be considered is calculated by multiplying the number of flights, by the number of passengers present on each flight, by the number hold bags presented by each passenger.

4.4.1.4 Availability of first ULD from inbound aircraft.

A ULD becomes available to be built for building departing baggage when the inbound flight ULDs are removed from the aircraft, the baggage contents are emptied, and the ULD is repositioned for flight departures build. It should be noted airlines do frequently however use local empty ULD racks which contain empty ULDs which be called upon during the flight open period. Hua-An Lu, Chien-Yi Chen (2011) propose a predicative model that describes the networked ULD movement behaviour experienced by a single airline; the model predicts the necessary quantities of ULDs that are needed to be positioned correctly in real time across the network airport locations. Depending on the type of airline, airport location, and ultimate demand, airlines will use inbound ULD, stored or buffered ULDs, and shared airline ULDs. Sharing of ULDs across multiple airline carriers does occur, but is less commonplace.

For Code C loose load aircraft, baggage carts are used which can be built as soon as the ATL baggage is available, and the baggage cart has been positioned for a flight build.

4.5 Build availability equation

The equation ...29 describes the availability of all ATL bags, on all flights, built into either short haul baggage carts, or long haul baggage ULD equipment, when the ULDs become available from an inbound arriving flight.

A product formula is proposed comprising of three core components [A], [B], and [C];

$$\mathrm{Qbb} = [A] \text{ x } [B] \text{ x } [C] \qquad \text{... 29}$$

Where:

(i) Qbb is the total quantity of all ATL bags built, from all flights, which are built into ULDs that have arrived on an inbound aircraft, within the specified integral period.

(ii) The component [A] defines the delivery rate behaviour of the baggage entering the baggage system for any flight. Component [A] is integrated between the lower limit, and upper time limit interval. This time interval is the period that the inbound aircraft can make ULDs available for outbound aircraft build activities.

$$A = \left[\int_{LL}^{UL} (\lambda\, \vartheta)\right]$$

... 30

(iii) The component [B] is a multiplying factor that defines the percentage of baggage within the baggage system for the outbound aircraft which is authorised to be built. This is referenced to as the ATL probability factor (K_{ATL}). The K_{ATL} value is a set value for long haul traffic and for short haul traffic operations, and has been derived from historic actual witnessed data defined in the research paper published by Bradley et al (2012).

$$B = [K_{ATL-LH}]\ or\ [K_{ATL-SH}]$$

... 31

(iv) The component [C] defines the number of baggage on the aircraft and references data contained in Table 3 that follows.

$$C = [Number\ of\ Bags\ on\ Flight\ ] = [Number\ of\ Flights] \times \frac{Pax}{Flight} \times \frac{Bags}{Pax}$$

... 32

and where the integration limits are denoted by…

Lower Limit (LL) = STD first empty ULD or baggage cart arrives at the build area

Upper Limit (UL) = STD last empty ULD or baggage cart arrives at the build area

K_{ATL} (short haul) = 92%

K_{ATL} (long haul) = 70% - 90% (STD dependent)

The product of the components [A], [B], and [C] calculates the results shown in Table 4 that follows.

To use the ULD storage capacity method defined herein the following variables must be determined:

(i) Defining if the aircraft to be considered: long haul or short haul flight;

(ii) Confirming the integral time period between, brake on time of the inbound aircraft and the STD of the outbound aircraft;

(iii) Confirming the number of passengers on the outbound aircraft;

(iv) Confirming the bag to passenger ratio for passengers on the outbound aircraft.

The variables (i), (ii), (iii), and (iv) above are referenced within the model, and can be seen on the input variable worksheet, (Appendix B).

Authorised to load (ATL) bags are permitted to be built into a ULD or a baggage cart, and then placed into the hold of an outbound aircraft. Unauthorised to be loaded (UTL) baggage is not permitted to be loaded onto an aircraft. Each piece of hold baggage has a corresponding baggage source message (BSM) set of data which is attributed to each of the unique IATA baggage tags; the ATL/UTL baggage status is confirmed in the BSM whilst the bags are in transit within the system.

The UTL to ATL status transition is usually made when the airline is certain that: (a) the bag has cleared the hold baggage security screening processes, and (b) bag to passenger reconciliation has occurred. This is where a positive match has been confirmed, approximately at STD-30, that a passenger's bag(s), and the corresponding passenger have been reconciled in the flight manifest.

4.5.1 Tabulated results: percentage of bags built

The product of component [A] multiplied by [B] calculates the percentage of baggage on the specific aircraft considered, that can be built into available ULDs, reusing the inbound arriving aircraft ULDs, to provide the departing outbound aircraft with ULDs.

Table 3 lists the output of component [A] x [B] for each of the considered aircraft, where the variable "brakes on time" ranges from 30 minutes to 300 minutes for the inbound aircraft relative to a common STD timeline.

Table 3: Product [A] x [B] - Percentage of bags built, varying brakes on time before STD

Aircraft Characteristics					Inbound aircraft brakes on time before STD (Mins)									
Aircraft	Series	Aircraft turn around time (Mins)	Time to unload aircraft belly (Mins)	Time to load aircraft belly (Mins)	30	60	90	120	150	180	210	240	270	300
					% Of bags built using inbound aircraft ULDs									
Boeing 737	800W	38	6	9	0	0	0	0	0	0	0	0	0	0
Boeing 757	300	34	7	13	0	0	0	0	0	0	0	0	0	0
Boeing 777	200-LR	45	18	18	0	1	7	23	43	60	73	81	85	88
Boeing 747	800	110	20	22	0	0	6	22	41	59	72	80	85	88
Boeing 787	800	44	16	16	0	1	8	24	44	61	74	81	86	88
Airbus A318	100	19	6	6	0	2	13	31	50	66	77	83	87	88
Airbus A320	200	23	6	6	0	2	13	31	50	66	77	83	87	88
Airbus A340	600	63	20	20	0	0	6	22	41	59	72	80	85	88
Airbus A380	800	90	37	27	0	0	2	12	30	49	65	76	83	86

The non-containerised aircraft (B737 and B757) shown in Table 3 are not reliant on the presence of ULDs to enable these aircraft to be loaded with departing baggage. It is for this reason that 0% is reported in Table 3 against these aircraft types.

4.5.2 Tabulated results: Number of bags built

Table 4 lists the output of equation …29 fully, where components [A] x [B] x [C] are shown for each of the considered aircraft, and where the variable "brakes on time" ranges from 30 minutes to 300 minutes for the inbound aircraft relative to a common STD timeline.

Table 4: Product [A] x [B] x [C]: Number of bags built, varying brakes on time before STD

		Aircraft Characteristics			Inbound aircraft brakes on time before STD (Mins)									
Aircraft	Series	Aircraft turn around time (Mins)	Time to unload aircraft belly (Mins)	Time to load aircraft belly (Mins)	30	60	90	120	150	180	210	240	270	300
					Product [A] x [B] x [C] # of bags built using inbound aircraft ULDs									
Boeing 737	800W	38	6	9	0	0	0	0	0	0	0	0	0	0
Boeing 757	300	34	7	13	0	0	0	0	0	0	0	0	0	0
Boeing 777	200-LR	45	18	18	0	6	42	139	260	362	441	489	513	532
Boeing 747	800	110	20	22	0	0	43	158	294	423	516	574	609	631
Boeing 787	800	44	16	16	0	5	42	127	233	323	391	428	455	466
Airbus A318	100	19	6	6	0	**4**	25	59	95	125	146	157	164	166
Airbus A320	200	23	6	6	0	3	17	41	66	87	102	110	115	116
Airbus A340	600	63	20	20	0	0	20	75	139	201	245	272	289	299
Airbus A380	800	90	37	27	0	0	14	86	215	**351**	466	545	595	617

4.5.2.1 Code C aircraft ULD storage requirements

With reference to table 4 at STD 60 minutes, for the Airbus A318 (a typical code C aircraft), only 4 bags out of 166 bags can be built using the inbound aircraft available ULDs. It follows then, as seen in table 5, that the full quota of ULDs need to be provided to service this aircraft, and must be pre-stored at the airport.

4.5.2.2 Code F aircraft ULD storage requirements

Similarly, with reference to table 4 at STD -180 minutes for the Airbus A380 (code F aircraft) only 351 bags out of 617 bags can be built using the inbound aircraft available ULDs. It follows then, as seen in table 5, that a partial quota of ~20 ULDs need to be provided to service this aircraft and must be pre-stored at the airport.

Table 5: Number of ULDs needed to be stored at the airport to service outbound aircraft, varying brakes on time before STD.

Aircraft Characteristics			Inbound aircraft brakes on time before STD (Mins)									
Aircraft	Series	(Total # of ULDs on aircraft)	30	60	90	120	150	180	210	240	270	300
			Number of ULDs needed to be stored at the airport to service outbound aircraft									
Boeing 737	800W	0	0	0	0	0	0	0	0	0	0	0
Boeing 757	300	0	0	0	0	0	0	0	0	0	0	0
Boeing 777	200-LR	32	32	32	30	25	19	13	9	7	5	4
Boeing 747	800	38	38	38	36	30	23	16	11	8	6	5
Boeing 787	800	28	28	28	26	22	16	11	8	6	4	4
Airbus A318	100	10	10	**10**	9	7	5	4	3	2	2	2
Airbus A320	200	7	7	7	7	5	4	3	2	2	1	1
Airbus A340	600	18	18	18	17	15	11	8	6	4	3	3
Airbus A380	800	38	38	38	38	34	27	**20**	14	10	7	6

4.5.3 Tabulated results: Number of ULDs to be stored locally

Table 5 lists the quantity of ULDs needed to be stored locally for each of the considered aircraft, where the variable “brakes on time” ranges from 30 minutes to 300 minutes for the inbound aircraft relative to a common STD timeline.

The quantity of the Component f2, ULD Powered Rollerbed, used to store ULDs is defined by the equations, (15, 16, and 17). These equations use two constant values 10, and 20 that derived from Table 5. The value of 10 ULDs to be stored per typical

Code C (short haul containerised) Airbus A318 – 100 series aircraft, which parks and has a brakes on time at STD-60 minutes is used, and the value of 20 ULDs to be stored per typical Code F (long haul containerised) Airbus A380 – 800 series aircraft, which parks, and has a brakes on time at STD-180 minutes is used. This defines the total ULD storage needed to meet the operational requirements for any given code C and Code F flight input schedule.

4.6 Chapter summary

In summary Chapter 4 has explained how bags enter the BHS using the proposed Gamma equation, and how the model deals with this. This Gamma equation has also been used to define two constants used within the model, such that the quantity of ULDs that need to be stored per flight type processed can be calculated. It was necessary to fully understand this relationship, and these ULD constants since they have an impact upon the building solution size that are ultimately required, and calculated by the model.

5. CAPITAL OPERATING AND WHOLE LIFE CYCLE COSTS

5.1 Introduction to costs

The principle purpose of Chapter 5 is to explain what capital and operating costs were used within the model, and how these values were derived. Furthermore this Chapter explains the financial modeling technique that was selected. A series of questions were asked and are answered which support the financial modeling proposal.

Table 6 that follows provides a summary of the capital, and operating costs that have been referenced within the model. The capital costs of equipment are costs without the manufacturers profit margin applied. The capital, and the annual operating running costs of each component, plus the salary cost values of the staff that would be deployed, were obtained through interviews and meetings with Cowper (2010), Dolye (2010), Shortland (2010), Stewart (2010), Unwin (2009), and Wood (2010). This data is contained within Appendix G.

In Chapter 3 the electro mechanical components used within the three BHS types is constructed and defined. With the specification of the three types electro mechanical systems established it is then necessary to summarize their costs. To do this one must first ask some questions that will help determine how the costs shall be constructed, what tests should be carried out, and what financial evaluation technique should be used.

These questions were noted to be:

1. How can BHSs that do not actually exist yet be compared consistently?
2. What factors could affect a financial comparison of BHSs?
3. What financial assessment approach should be used to compare BHSs?

5.1.1 How can BHSs that do not actually exist yet be compared consistently?

Airport operators, BHS design consultants, and BHS suppliers are naturally normally reluctant to divulge commercial capital, and moreover operating cost information pertaining to the development of BHSs. This is because the information is commercially sensitive, and could be used to the detriment of these organisations. BHSs are designed to meet airport specific forecasted baggage input demands, and it is impossible to obtain capital cost, and operating cost data for the sets of experiments that are needed and explained in this Chapter. This information is both difficult to get hold of and arguably of little value when received as there are often inconsistencies with the data that is provided. For example, if two organisations are asked the same question, to provide capital costs of their airports BHS, it is highly probable that the data received will contain a different set of capital cost build up assumptions. For this reason it was necessary to construct the model which was then subjected to the different input demand requirements. The consistent electro mechanical construction approach, detailed in Chapter 3 produces directly comparable results.

Table 6: Model component capital production costs and operating costs per annum (quarter 4 2011 prices)

Comp. ID	Sub System Technology	CAPEX £'s	OPEX £'s Per Annum	Area m^2
a1	Conventional Conveyor (3x1.2m assembly)	Ca1: £13,481	Oa1: £5,447	Aa1: 5.40m^2
b1	Collector Belt (1x20m)	Cb1: £6,877	Ob1: £6,937	Ab1:30.00m^2
b4	Powered Belt Curve	Cb4: £31,800	Ob4: £3,631	Ab4: 4.91m^2
c1	Conveyor Lane Q conveyors (1x1.2m)	Cc1: £3,000	Oc1: £2,696	Ac1: 1.80m^2
d1	Standard 2 Level 1 Unit	Cd1: £250,000	Od1: £29,156	Ad1:25.00m^2
d2	Standard 2 Level 3 Unit	Cd2: £750,000	Od2: £62,156	Ad2:33.75m^2
d3	Standard 2 Level 2 Workstation	Cd3: £15,000	Od3: £209	Ad3: 1.00m^2
e1	Flight Lateral (1x28m)	Ce1: £14,894	Oe1: £8,177	Ae1: 210m^2
e3	Flight Racetracks (1x40m length unit)	Ce3: £21,972	Oe3:£7,392	Ae3:504.0m^2
e7	Merge VSU	Ce7: £32,417	Oe7: £5,196	Ae7: 4.50m^2
e9	Divert VSU	Ce9: £31,336	Oe9: £5,196	Ae9: 4.50m^2
e10	Indexing	Ce10: £9,725	Oe10: £2,098	Ae10:5.40m^2
e11	Sortation induct	Ce11: £38,900	Oe11: £3,816	Ae11:5.40m^2
e12	Sortation loop (10m per lateral pitch needed)	Ce12: £6,483	Oe12:£816	Ae12:15.0m^2
e21	Power bus (1 off assembly) unit)	Ce21: £1,439,306	Oe21: £1,000	Ae21: 0m^2
e22	Scanner array (1 unit)	Ce22: £39,981	Oe22: £3,109	Ae22: .20m^2
f2	ULD Powered Rollerbed (1x2m rollerbed)	Cf2: £20,000	Of2: £5,262	Af2: 16.00m^2
g1	Robotics (Grenzebach)	Cg1: £392,000	Og1: £4,196	Ag1: 0.00m^2
g2	Manipulator (RTT type unit)	Cg2: £58,000	Og2: £4,196	Ag2: 6.00m^2
h1	Power Conditioner (1 off per facility)	Ch1: £5,000	Oh1: £663	Ah1: 2.00m^2
h2	Power Incomer (1 off per drive)	Ch2: £1,081	Oh2: £500	Ah2: 0.05m^2
h3	Motor Controllers (1 off)	Ch3: £15,000	Oh3: £1,163	Ah3: 5.00m^2
h4	Programmable Controller Computer (1 off)	Ch4: £10,000	Oh4: £5,272	Ah4: 1.00m^2
h5	Programmable Controller Module (1 off)	Ch5: £2,161	Oh5: £1,272	Ah5: 0.05m^2
h6	Programmable Controller Software	Ch6: £10,000	Oh6: £1,272	Ah6: 0m^2
h7	Sort Allocation Computer	Ch7: £483,010	Oh7: £5,272	Ah7: 2.00m^2
h8	Control System Computer and Display	Ch8: £15,000	Oh8: £10,272	Ah8: 1.00m^2
h9	Safety Equipment (per drive)	Ch9: £1,081	Oh9: £511	Ah9: 0.05m^2
h10	Network (per drive)	Ch10: £108,056	Oh10: £611	Ah10: 0m^2
h11	SCADA system (base hardware / software)	Ch11: £131,828	Oh11: £10,272	Ah11:2.00m^2
i1	Manual loader (lateral racetrack chute)	N/A	Oi1: £30,850	Ai1: 1.50m^2
i2	Manual loader (Robotics support & top up)	N/A	Oi2: £30,850	Ai2: 1.50m^2
i3	Manual loader (RTT)	N/A	Oi3: £30,850	Ai3: 1.50m^2
j1	Platform (per m run)	Cj1: £1,081	Oj1: £10	Aj1: 0m^2
j3	Stairs (per ladder)	Cj3: £2,161	Oj3: £15	Aj3: 0m^2
k1	Fire door (per door)	Ck1: £14,047	Ok1: £1,000	Ak1: 2.00m^2

5.1.2 What factors could affect a financial comparison of BHSs?

There are factors which can have an affect on the commercial comparison of the BHSs. The full set of test sensitivities, as outlined later in Table 7, were applied, to investigate how the financial results could be affected by factors that might vary, such as, though not limited to:

(i) Inflation;

(ii) Regional/country staff costs;

(iii) Regional /country capital cost variations;

(iv) Regional /country staff bag loading performance.

5.1.3 What financial assessment approach should be used to compare BHSs?

The model was then constructed to address the aforementioned issues. The processes, component descriptions, functions, the BHS component and assembly rules are all embedded within the model equations (see section 3.3). As explained within Chapter 2, the WLCC NPV financial appraisal technique is widely adopted by airports when assessing and comparing the overall long term costs of major developments such as BHS developments, which contain revenue income streams such as the bag processing charge. It is for this reason that this WLCC NPV approach has been programmed into the model (see Appendix I WLCC NPV worksheet).

5.2 Capital costs model equations

This section explains the equations used to surmise the capital, and operating costs of the BHS solutions that have been constructed within the model environment. The individual component capital costs, and component areas are defined within Table 6.

The total capital cost of a BHS solution is given by the equation:

$$CAPEX_{Total} = CAPEX_{Baggage\ System} + CAPEX_{Baggage\ Building} + On\ Cost \ldots\ldots 33$$

Where

(i) Building rate $_{CONSTRUCTION}$ = £2,981/m^2. This is the building construction cost per m^2 rate, and is further defined within the following clause 5.10 Baggage Building: Capital Cost Rates.

(ii) CAPEX $_{Baggage\ System}$

$$\sum[(Na1xCa1)+(Nb1xCb1)+(Nb4xCb4)+(Nc1xCc1)+(Nd1xCd1)+(Nd2xCd2)$$
$$+(Nd3xCd3)+(Ne1xCe1)+(Ne3xCe3)+(Ne7xCe7)+(Ne9xCe9)+(Ne10xCe10)$$
$$+(Ne11xCe11)+(Ne12xCe12)+(Ne21xCe21)+(Ne22xCe22)+(Nf2xCf2)+$$
$$(Ng1xCg1)+(Ng2xCg2)+(Nh1xCh1)+(Nh2xCh2)+(Nh3xCh3)+(Nh4xCh4)+$$
$$(Nh5xCh5)+(Nh6xCh6)+(Nh7xCh7)+(Nh8xCh8)+(Nh9xCh9)+(Nh10xCh10)$$
$$+(Nh11xCh11)+(Nj1xCj1)+(Nj3xCj3)+(Nk1xCk1)]$$

(iii) CAPEX $_{Baggage\ Building}$ =

$$\sum[((Na1xAa1)+(Nb1xAb1)+(Nb4xAb4)+(Nc1xAc1)+(Nd1xAd1)+$$
$$(Nd2xAd2)+(Nd3xAd3)+(Ne1xAe1)+(Ne3xAe3)+(Ne7xAe7)+(Ne9xAe9)+$$
$$(Ne10xAe10)+(Ne11xAe11)+(Ne12xAe12)+(Ne21xAe21)+(Ne22xAe22)+$$
$$(Nf2xAf2)+(Ng1xAg1)+(Ng2xAg2)+(Nh1xAh1)+(Nh2xAh2)+(Nh3xAh3)+$$
$$(Nh4xAh4)+(Nh5xAh5)+(Nh6xAh6)+(Nh7xAh7)+(Nh8xAh8)+(Nh9xAh9)+$$
$$(Nh10xAh10)+(Nh11xAh11)+(Ni1xAi1)+(Ni2xAi2)+(Ni3xAi3)+(Nj1xAj1)+$$
$$(Nj3xAj3)+(Nk1xAk1))\ x\ Building\ rate_{CONSTRUCTION}]$$

(iv) The number (quantity) of each component used is defined within clauses 3.3.2 (Na1) through to 3.3.36 (Nk1) inclusive.

(v) On cost is calculated to be the ratio 0.47 x CAPEX $_{\text{Baggage System}}$. This ratio is defined within the following clause 5.7 Commercial WLCC NPV Worksheet.

5.3 Operating costs model equations

This section explains what is contained within the operating costs of the BHS and the encompassing BHS building. The individual BHS component level annual operating costs, and component areas are defined within Table 6.

The total operating cost of a BHS solution is given by the equation:

$$\text{OPEX}_{\text{Total}} = \text{OPEX}_{\text{Baggage System}} + \text{OPEX}_{\text{Baggage Building}} \qquad \ldots\ldots 34$$

Where

(i) OPEX $_{\text{Baggage System}}$ =

$$\sum\Big[(Na1xOa1)+(Nb1xOb1)+(Nb4xOb4)+(Nc1xOc1)+(Nd1xOd1)+(Nd2xOd2) +(Nd3xOd3)+(Ne1xOe1)+(Ne3xOe3)+(Ne7xOe7)+(Ne9xOe9)+(Ne10xOe10) +(Ne11xOe11)+(Ne12xOe12)+(Ne21xOe21)+(Ne22xOe22)+(Nf2xOf2)+ (Ng1xOg1)+(Ng2xOg2)+(Nh1xOh1)+(Nh2xOh2)+(Nh3xOh3)+(Nh4xOh4)+ (Nh5xOh5)+(Nh6xOh6)+(Nh7xOh7)+(Nh8xOh8)+(Nh9xOh9)+(Nh10xOh10) +(Nh11xOh11)+(Ni1xOi1)+(Ni2xOi2)+(Ni3xOi3)+(Nj1xOj1)+(Nj3xOj3)+(Nk1xOk1)\Big]$$

(ii) Building $_{\text{HVAC}}$ = £12/m^2/Annum) rate. This is the annual rate per m^2 allocated for heating, ventilation and lighting of the BHS building. These are 2011 quarter 4 prices, Briggs (2009).

(iii) Building $_{\text{MAINTENANCE}}$ = £54/m^2/Annum) rate. This is the annual rate per m^2 allocated for Maintenance Building of the BHS building. These are 2011 quarter 4 prices, Briggs (2009).

(iv) OPEX $_{\text{Baggage Building}}$ =

$$\sum\Big[\Big((Na1xAa1)+(Nb1xAb1)+(Nb4xAb4)+(Nc1xAc1)+(Nd1xAd1)+$$

$$(Nd2xAd2)+(Nd3xAd3)+(Ne1xAe1)+(Ne3xAe3)+(Ne7xAe7)+(Ne9xAe9)+$$

$$(Ne10xAe10)+(Ne11xAe11)+(Ne12xAe12)+(Ne21xAe21)+(Ne22xAe22)+$$

$$(Nf2xAf2)+(Ng1xAg1)+(Ng2xAg2)+(Nh1xAh1)+(Nh2xAh2)+(Nh3xAh3)+$$

$$(Nh4xAh4)+(Nh5xAh5)+(Nh6xAh6)+(Nh7xAh7)+(Nh8xAh8)+(Nh9xAh9)+$$

$$(Nh10xAh10)+(Nh11xAh11)+(Ni1xAi1)+(Ni2xAi2)+(Ni3xAi3)+(Nj1xAj1)+$$

$$(Nj3xAj3)+(Nk1xAk1)\Big) \text{ x (Building }_{\text{HVAC}}\text{+Building }_{\text{MAINTENANCE}})\Big]$$

(v) The CAPEX $_{\text{Total}}$ and the OPEX $_{\text{Total}}$ for each of the BHS types are then entered into the WLCC NPV worksheet as described in section 5.7 that follows.

5.4 Model: Financial appraisal technique (FAT)

This section explains which FAT tool has been used within the model. The financial issues that are unique to the development and operation of BHSs are defined.

As denoted in section 2.2 during the research stage it was established that airport operators use FAT evaluation techniques which calculate the IRR, EBITDA and WLCC NPV. They use these FAT tools when considering the merits of future major capital development projects. The question then presented itself: which FAT tool should be used that will best evaluate the value of the various types of BHSs that are to be compared? New BHSs will have considerable capital[46] and revenue[47] costs. The revenue operating cost is an annual repeated cost through the lifespan of the project, which in some instances is not fully recovered at all airports, through a single separate income recovery mechanism. The User Group are charged to operate BHSs through a dedicated "bag charge" and the BHS capital development costs are commonly recovered through a landing fee, which is usually part of a group of projects within a much larger capital investment plan. This thesis concentrates on the comparison of the WLCC commercial viability of the BHS and its associated BHS building infrastructure. The FAT used within this thesis encapsulates the capital cost, operating cost and income revenue stream (bag charge) variables of just the BHSs. The WLCC NPV FAT provides meaningful comparable results when capital costs, operating costs, and income stream variables are provided. The WLCC NPV approach was selected as the commercial model to adopt to compare the various types of baggage development that are designed by the model. The WLCC NPV approach is internationally regarded as an appropriate financial appraisal technique to use, and is widely used in the engineering industry, construction industry, and by accountants, that are trying to establish the optimum financial return of various developments.

5.5 Assumptions: model

The model incorporates the following assumptions / settings that have been used within the programming:

(i) The model has been programmed to develop BHS that require an Early Baggage Store using the defined component c1. This is based on the lane conveyor technology instead of the crane and rack solution. The lane solution

[46] Capital Baggage Costs: Definition - these are the costs to purchase and install the BHS
[47] Revenue Baggage Costs: Definition - These are the costs to run the baggage operation

occupies more space than the comparative crane solution and consumes more energy;

(ii) A fully automatic BHS incorporates a 25% proportion of robotic build cell technology, and a 75% proportion of conventional lateral build technology;

(iii) A semi-automatic BHS incorporates a 25% proportion of RTT build cell technology, and a 75% proportion of conventional lateral build technology;

(iv) A manual BHS incorporates 100% conventional racetrack output device technology;

(v) The energy consumption calculation uses an energy unit rate of £0.16 per KW hour (this is 2011 UK rate available to a UK airport consumer) this rate shall vary from consumer to consumer, and from year to year;

(vi) All assets take 1 year to build and then all are put into full operation;

(vii) Business land rates have not been included within the model;

(viii) All assets are paid for in year 1;

(ix) All assets have a residual value of zero GB£'s in Year 15;

(x) Building assets have an asset life of 15 years;

(xi) Baggage system assets have an asset life of 15 years (BHS suppliers normally specify a 15 year life span for BHS equipment);

(xii) Inflation is applied to the annual OPEX and Bag charge, where 1% (Low), 3% (Base), and 7% (High). The low, base and, high inflation values were selected following reference to data obtained from the UK Office of National Statistics (see Figure 6);

(xiii) The WLCC NPV calculation is based on Q4 2011 CAPEX and OPEX costs;

(xiv) The model does not address issues associated with staff health and safety;

(xv) After the initial capital spend investments have been made, the model makes no further provision for capital spend throughout the 15 year life period, All BHS equipment and buildings are considered to be maintainable.

5.5.1 Inflation rate duration

When calculating the WLCC NPV, the model references the inflation rate that is set as an input at the start (year 1); this rate is then maintained throughout the lifespan of the project (to year "N"). In reality inflation rates rarely remain constant over prolonged periods (refer to section 2.2.1 - Inflation Ranges Figure 6). Whilst this programmed in assumption is reasonable for experimentation purposes, the reality is that a model predicted WLCC NPV will be not be absolute due to inflation variations that are likely to be witnessed in the real world environment.

5.5.2 Construction time

The model assumes that a BHS asset takes 1 year to construct, then the asset is put into full operational use. The model also assumes that all assets are paid for by the end of year 1. Whilst this construction period is realistic, some projects can take less than or longer than 1 year to build. BHSs that take less than or longer than the stated assumed 1 year build period, would respectively bring forward, or delay the income stream from any bag charge. This in turn would change the WLCC NPVs during this period.

5.5.3 BHS land costs

The cost of the land that is required to build an airport BHS on, can vary considerably from airport to airport. Land prices can be influenced by, though not limited to:

(i) Supply and demand of available land;

(ii) Planning permission status of available land;

(iii) Government policy for the development of airports on identified land;

(iv) Environmental sensitivity of available land.

If the land is not already owned by the airport then this would need to be taken into account within the WLCC NPV capital costs provisions. Since the variation in land costs can be significant, and because many airports already own the land that BHSs get built on, the model is programmed to assume that there is a zero cost to purchase land to build the BHS.

5.6 Capacity enabling and asset replacement developments

A capacity enabling BHS development is one which provides further new BHS throughput capacity, whereas a life expired asset replacement development merely replaces assets which are worn out, and does not increase BHS throughput capacity.

The capacity enabling developments can be built on green field sites, or be developed on brown field sites. The life expired asset replacement developments usually retain the existing BHS building infrastructure.

The WLCC NPV results provided in Chapter 6 that follows relate to the development of green field BHS sites since it is assumed in the model that there is a need to build a new building to house the designed BHS. Brown field sites that use existing infrastructure are not represented in the WLCC NPV results contained in Chapter 6.

The Specialist Group, and the User Group defined in Chapter 1 will need to calculate the CAPEX, OPEX, and WLCC NPVs of capacity enabling developments, and life expired asset replacement developments. The results contained in Appendix H provide CAPEX and OPEX information for both the building and the BHS components for the stated bag flow rates, and input sensitivities.

5.7 Commercial WLCC NPV worksheet

The CAPEX and OPEX values that are determined within the assembly environment worksheet (see Appendix E) are then processed through the WLCC NPV cost worksheet for each flight schedule input (see Appendix I). This section explains what factors are incorporated, and how the WLCC NPV values are determined.

The WLCC NPV equation takes into account: (i) Capital costs, (ii) Operating costs, and (iii) Income from the Bag Charges. The Capital Cost is built up of: (i) Baggage Building CAPEX, (ii) Baggage System CAPEX, and the Construction "On-costs" capital expenditure. These values are inputs from the assembly environment worksheet (see Appendix I).

The capital cost of the baggage system and the baggage building is recorded in the WLCC NPV worksheet at the beginning of year 1. As the baggage handling system and the baggage building age, so their worth or value is reduced. At the end of the declared asset life (15 years[48] for the BHS, and 15 years[49] for the Baggage Building), these assets have a residual book value[50] of zero GB pounds.

[48] BHS life: 15 years is the guaranteed life period declared by BHS system suppliers for a BHS solution.

The "on costs[51]" of the assets were calculated by multiplying the BHS CAPEX by the factor 0.47. This factor value was derived from an actual cost plan of a recent major BHS project based in the UK. These values do naturally change, depending on the complexity of the BHS project, the 0.47 value used was verified by an independent cost consultant as being a typical percentage to use, Bellamy P (2009).

The operating cost is calculated to be a year on year cost within the WLCC NPV calculation worksheet. The operating cost incorporates: (i) Baggage OPEX (including inflation), and (ii) Building OPEX (including inflation). Both the annual Baggage OPEX, and the annual Building OPEX values are derived from the assembly environment worksheet, and each year the declared 3% inflation is added.

The WLCC NPV calculation incorporates a bag charge income stream per annum. The airport operator often will charge the airlines for the quantity of bags that it processes through the airport.

5.7.1 Bag charge income stream

The bag charge is calculated by multiplying the Bags / Hour rate as shown on the input variables worksheet by 18 hours[52] (the number of operational hours in a day) and then multiplying this by 365 days in a year. This value is then multiplied by the

[49] Building life: 15 years is the guaranteed life period commonly used by airports for airport BHS buildings. This period can vary between 15 -25 years for commercial BHS building assets. Once a building life has expired it is common to demolish or re-life the building asset.
[50] Residual book value: This is the value of an asset at the end of its life period, noted in Year 15 to be £0 for both the baggage handling system and the baggage building assets. No residual value.
[51] On costs: These are the costs of designing and managing the construction of the BHS and the BHS buildings.
[52] Operational hours are denoted to be 18 hours per day: Heathrow, Stansted, and Gatwick airports typically have night time shut down periods between 24:00 hours, and 06:00 hours, this means the BHS can be operational for 18 hours per day. These examples have been used to determine a realistic operational day period.

BHS utilization factor[53] (50%), as all BHSs are not fully utilized throughout the operational day. The result is then multiplied by the OPEX factor[54] declared on the input variables worksheet, and then multiplied by the set bag charge value (£1/bag[55]). In each year of operation the bag charge is increased by the inflation factor, which is set according to the inflation rate percentage stated in the sensitivity test (See table 7 that follows).

The BAG CHARGE $_{Total}$ equation is then given by:

$$BAG\ CHARGE_{Total} = \sum_{n=0}^{n=15} \left[\text{Bags/Hour x 18 x 365 x 50\% x OPEX factor x £1 x Inflation factor} \right] \qquad \ldots\ldots 35$$

Where

(i) n = year 0 to 15 inclusive.

(ii) Inflation rate percentage is 1% (0.01 - low), 3% (0.03 - base) and 7% (0.07 - high).

(iii) The inflation factor = (1 + Inflation rate percentage)^{n}

5.7.2 WLCC NPV calculation

The WLCC NPV at the 15 year period is the true measure of value as this coincides with the life period of the BHS asset. Whilst the guaranteed life of a BHS is normally 15 years these BHSs are often kept in operation for longer than this period. Once the BHS asset has been fully paid for, and on the premise that the annual OPEX total is

[53] BHS utilization factor 50%: This factor value will vary from airport to airport depending on the demand forecast flight schedule. 50% utilization represents a BHS which typically incorporates morning and afternoon peak periods and lower BHS utilization outside of these periods.
[54] The OPEX factor is used to adjust the bag charge to local national variations.
[55] Bag Charge £1/bag processed: This value can be set to recover the cost of operating the BHS. A consistent nominal value of £1 / bag processed was set for all experiments.

less than annual income revenue generated through the bag charge, it would then be possible to generate positive WLCC NPV cash flows.

The bag charge value that is used can significantly affect the payback period for a BHS development. This is because the quantity of bags processed within a BHS is generally a large value per annum, even when it is assumed that the BHS has a realistic 50% BHS utilization factor.

The WLCC NPV equation is then given by:

$$WLCC\ NPV = \sum_{n=0}^{n=15}{}_{\mathrm{NPV}} \left[\left(\left(CAPEX_{Total} + OPEX_{Total} + BAG\ CHARGE_{Total}\right) \times DCF\right)\right] \qquad \text{…... 36}$$

Source: Atril, (2013), Haste Doug, (2014)

Where...

(i) CAPEX $_{\mathrm{Total}}$ is a capital outgoing (negative value).

(ii) OPEX $_{\mathrm{Total}}$ is an annual operating cost outgoing (negative value).

(iii) BAG CHARGE $_{\mathrm{Total}}$ is noted to be an annual accumulative income stream (positive value), that effectively reduces the WLCC. Please refer to the preceding clause 5.7.1 Bag charge income stream for further details.

(iv) *n* = year 0 to 15 inclusive.

(v) DCF = Discounted Cash Flow Factor in year "n" producing a present value

The DCF equation is given by:

$$DCF = \frac{Cn}{(1+r)^n} \qquad \text{…... 37}$$

Source: Atril, (2013), Briscoe, (1990), Tracy, (2012).

Where…

Cn = Cash flow in year *n*.

r = Discount rate (3.375% [56] + 4.5%[57] = 7.875%). This discount rate calculation method determines the minimum expected return on capital, source: Tracy, (2012)

5.8 International CAPEX / OPEX / Inflation variations

This section explains the international capital (CAPEX), and operating (OPEX) cost multiplying factors that exist, and that can be applied to the model. These factors are used when trying to establish the relative cost of worldwide developments, when measured against the cost of projects delivered in the United Kingdom; these factors are provided by IATA (2004). This section (see Appendix K) provides sample CAPEX and OPEX factors for selective countries, and explains the reasons why the maximum, and the minimum factors were selected for the tests that were carried out.

The cost to deliver, and operate BHSs varies according to which country the development is residing within. The reasons why there are international cost variations includes, but is not limited to:

- Construction staff wages;
- Operational staff wages;
- Commodity prices;
- Land prices
- Raw material supply costs;
- Currency exchange rates;

[56] Bank of England 20th Oct 2013: Base rate average (3rd Dec 2001 - 31st Dec 2011) = 3.375%
[57] CA Bank 20th Oct 2013: Typical corporate lending rate = 4.5%

The IATA (2004) Airport Development Reference Manual (Chapter U5) provides published adjustment factor[58] values for the major regions/countries of world. These factors permit the base UK prices stated to be adjusted to the region/country of interest. As the factors were benchmarked against UK prices, the CAPEX, and OPEX factors for the UK are noted to be a factor of 1.0. All of these published factors (total of 68 country specific factors) for the different regions of the world were added up, and it was noted that the maximum CAPEX / OPEX adjustment factor relative to UK prices was a 110% factor which was specific to the region of Asia Japan. The minimum CAPEX / OPEX adjustment factor relative to UK prices was a 19% factor which was specific to the region of Asia India. The mean CAPEX / OPEX adjustment factor of all 68 regions was calculated to be 59%. The 19% (Low), 59% (Base), and 110% (High) adjustment factors were then used within the test sensitivities that are detailed in Table 7 that follows.

[58] CAPEX / OPEX adjustment factor: The full list of IATA adjustment factors are in APPENDIX K

Table 7 defines the experimentation test sensitivities that have been completed.

Table 7: Experimentation test scenarios
Note: Bold text denotes the variable changed within the sensitivity test.

Experiment sensitivity	Input data used
BASE reference mid-range scenario World average	59% CAPEX factor applied 59% OPEX factor applied 3% inflation applied 2bags/min loading rate
High CAPEX factor scenario Asia Japan.	**110% CAPEX factor applied** 59% OPEX factor applied 3% inflation applied 2bags/min loading rate
Low CAPEX factor scenario Asia India	**19% CAPEX factor applied** 59% OPEX factor applied 3% inflation applied 2bags/min loading rate
High OPEX factor scenario Asia Japan.	59% CAPEX factor applied **110% OPEX factor applied** 3% inflation applied 2bags/min loading rate
Low OPEX factor scenario Asia India	59% CAPEX factor applied **19% OPEX factor applied** 3% inflation applied 2bags/min loading rate
High inflation rate scenario UK Office statistics high point	59% CAPEX factor applied 59% OPEX factor applied **7% inflation applied** 2bags/min loading rate
Low inflation rate scenario UK Office statistics low point	59% CAPEX factor applied 59% OPEX factor applied **1% inflation applied** 2bags/min loading rate
High staff loading rate (Bags/Min) scenario Industry measured high rate	59% CAPEX factor applied 59% OPEX factor applied 3% inflation applied **3bags/min loading rate**
Low loading rate (Bags/Min) scenario Industry measured low rate	59% CAPEX factor applied 59% OPEX factor applied 3% inflation applied **1bags/min loading rate**

The experiment sensitivities were designed to test the WLCC NPV impact of realistic variables that can confront a BHS designer, and/or an airport BHS developer trying to select the appropriate flight build technology.

The test sensitivities were completed using these three ranges of CAPEX / OPEX as well as ranges for inflation, and staff loading rate. The WLCC NPV output from these tests, have been recorded into the results database which is provided in Appendix H.

5.9 Staff Costs

This section explains how the base staff costs were derived from interviews from airline industry specialists, and how these costs were dealt within the model, and in turn informed the results documented in Appendix H.

BHSs require staff operatives to enable them to function. These operatives carry out three functions: (i) drive baggage tugs between the baggage hall, and the aircraft; (ii) remove bags from the BHS output positions, and; (iii) control the route selection of the BHS which the BHS does not automatically do.

To calculate the operating cost of any speculative baggage handling system, it is necessary to understand the staff salaries of the people that would operate the baggage system in total. Staff cost data is commercially sensitive, and has been difficult to obtain. To overcome this, staff cost questionnaires were discussed with handlers at Heathrow airport, and Gatwick airport. Completed questionnaires were received from IATA, Stewart, (2010), American Airlines, Dolye, (2010), Air Canada, Taylor, (2010), the London airline operating committee (AOC), Shortland (2010) and BAA, Cowper (2010).

During the interviews each of these individuals was requested to provide a BHS staff salary price (equivalent in GB pounds sterling Q4 2011). Appendix G explains the results of this survey of staff costs. The salary amounts did not include the full cost of employment, and excluded items such as staff benefit costs (e.g. company pension, employment taxes etc.). This cost was not included because it can vary considerably from country to country around the world, and if included would distort the results. It can be seen in Appendix G that the base, averaged staff cost, used throughout the investigation was £28,550. This value is used for each of the following component resources:

(i) Component I1	Handling Agent	Manual loader
(ii) Component I2	Manual loader	(Robotics support & top up)
(iii) Component I3	Manual loader	(RTT)

These base staff costs are multiplied by the OPEX factor input previously described in section 5.3.

The staff salary prices used within the model, represent a realistic cross section of market prices. Furthermore the salary costs are then regionally changed within the model whereby they are subjected to the high, low, and base case OPEX factors.

5.10 Baggage building: Capital cost rates

This section clarifies how the capital cost of the building has been determined using internationally published building rate data. The assumptions used are also defined.

The capital cost of the building is derived by establishing the total area of all of the components used within the BHS type. This value is then multiplied by the building rate as denoted in Appendix B on the input variables worksheet. IATA (2004) note that the regional terminal building rate to be £2,209/m^2, and the international terminal building rate to be £3,480/m^2. A real airport cost plan (based in the UK) provided a steel frame / cladding solution price of £3,254/m^2. The average of these rates was noted to be £2,981/m^2, and this value was used consistently within all the experiments (see Appendix B item 22).

The building CAPEX calculation is repeated for each of the BHS solutions types (manual/semi-automatic/fully automatic) as they each occupy different areas.

This means that different BHS building costs exist for the different BHS build solution technologies. This building cost approach has its limitations, which include:

(i) The presence of building columns, and heating and ventilation systems have not been factored in the area requirement of the building;

(ii) The presence of tug, and dolly[59] parking and passing road ways have not been factored into the area requirement of the building;

(iii) A common unit width for conveyors, including maintenance walkways of 1.5m has been provided;

[59] Dolly – this is the name of the trailer unit that holds ULDs.

(iv) This approach does not take into account the geometry of existing BHS halls, and assumes that the building can be built on an ideal green/brown field site with no restrictions;

(v) The building cost excludes any planning and land purchase costs that might exist;

Whilst there are limitations to this approach, the real intelligence is being able to compare the building costs financial delta[60] for the three separate BHS flight build options, where a constant building area rate is applied to the different building areas. This approach maintains accuracy, and also simplifies the comparison process allowing a truly like for like comparison of building costs to be obtained.

5.11 Chapter summary

In summary Chapter 5 has explained how the capital and the operating costs have been calculated. The assumptions imbedded within the model have been explained along with limitations of how the building costs were derived.

The method by which the WLCC NPV values have been calculated has been explained, along with the CAPEX, and OPEX variations that can be internationally expected. In turn these variations in CAPEX and OPEX are embedded into the experiments scenarios, and used as inputs to the model, so that the likely maximum, and minimum capital and revenue cost boundary conditions are fully tested, and the findings represented within the results that follow in Chapter 6.

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[60] Financial delta: Magnitude of cost between minimum BHS/Building cost solution, and maximum BHS/Building cost solution.

6. RESULTS

6.1 Introduction to results

This section explains what results have been obtained and included in Appendix H. The WLCC NPV results have been graphed to show the relationship between the three types of BHS solutions being evaluated. The graphs show:

1. Bags/Hr versus WLCC NPV total for each of the test sensitivities;
2. Bags/Hr versus WLCC NPV Summary Scatter Diagram all scenarios: long haul only, short haul only, and short haul and long haul mix;
3. Bags/Hr vs WLCC NPV Summary Block Diagram all scenarios: long haul only, short haul only, and short haul and long haul mix;
4. Close Inspections[61] of Cumulative Cost versus Year of operation for specific scenarios of particular interest, and importance.

6.2 Experimentation output (Matrix of data)

It was necessary to automate the process of running the tests to ensure that they were carried out in precisely the same way, and to ensure that the data output was recorded consistently. To achieve this aim a macro test script module was created within the model as denoted in subroutine macro defined within Appendix J.

6.3 Experiment group: Short haul flights / hour

It can be seen from the short haul only results provided in Appendix H that the short haul flight experiments consisted of increasing the quantity of short haul flights, in increments of 1 short haul flight per hour, from 1 short haul flight per hour, producing

[61] Close inspection: This examines the year 15 whole life cycle cost results in greater detail, by providing years 1 to 15 inclusive whole life cycle costs for the particular inspection scenarios examined.

180 bags per hour, upto 30 short haul flights per hour producing 5400 bags per hour. This approach ensured that for each sensitivity test all BHS categories A, B and C as defined by IATA (2004) would be evaluated.

6.4 Experiment group: Long haul flights / hour

It can be seen from the long haul only results provided in Appendix H that the long haul flight experiments consisted of increasing the quantity of long haul flights, in increments of 1 long haul flight per hour, from 1 long haul flight per hour, producing 480 bags per hour, upto 15 long haul flights per hour producing 7200 bags per hour. This approach ensured that for each sensitivity test all BHS categories A, B and C as defined by IATA (2004) would be evaluated.

6.5 Experiment group: Mix long / short haul flights / hour

It can be seen from the short haul and long haul mix results provided in Appendix H that these experiments consisted of increasing the quantity of short and long haul flights equally, in increments of 1 short haul flight per hour plus 1 long haul flight per hour, from 1 short haul flight and 1 long haul flight per hour, producing 660 bags per hour, upto 15 short haul and 15 long haul flights per hour producing 9900 bags per hour.

6.6 Sensitivity high CAPEX factor results

This section contains the results of the WLCC NPV experiments where the high CAPEX factor has been applied.

6.6.1 Re: Short haul only

It can be seen in Figure 29 that there are no positive WLCC NPV values. The high capital costs witnessed with the fully automatic BHS equipment solutions cannot be recovered through the OPEX savings that are expected within this type of solution through the use of robotics. The fully automatic BHS solution is the most expensive, the semi-automatic BHS solution is the second cheapest, and the manual BHS solution is the cheapest from a WLCC NPV perspective.

6.6.2 Re: Long haul only

It can be seen in Figure 30 that the processing of long haul flights only permits the higher capital costs on the more automated BHS solutions to be offset by the reduction in staff OPEX costs with these BHSs. Also it can be seen in Appendix H that there is a reduction in baggage hall areas witnessed with the semi-and fully automatic BHS solutions processing long haul flights. The fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

6.6.3 Re: Long haul short haul mix

In Figure 31 the higher capital cost of the automation equipment used within the semi-automated BHSs, can generally be recovered through OPEX savings with this solution. The semi-automated build lends itself to the processing the of the long haul component of the applied flight schedule input. This is due to the ability to process demand over the extended long haul flight open period. It can be seen in the results provided in Appendix H that the manual BHSs occupies more area, and require more staff than fully, and semi-automated BHS solutions.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

With reference to Figure 29, Figure 30 and Figure 31 where a high CAPEX is applied it is noted that the introduction of the long haul component to the input flight schedule has a considerable positive impact (reduces) upon the WLCC NPV for the fully and semi-automated BHS solutions.

When processing short haul traffic only, the introduction of the high CAPEX factor promotes the commercial ranking of the manual BHS solution type, when compared to the base conditions.

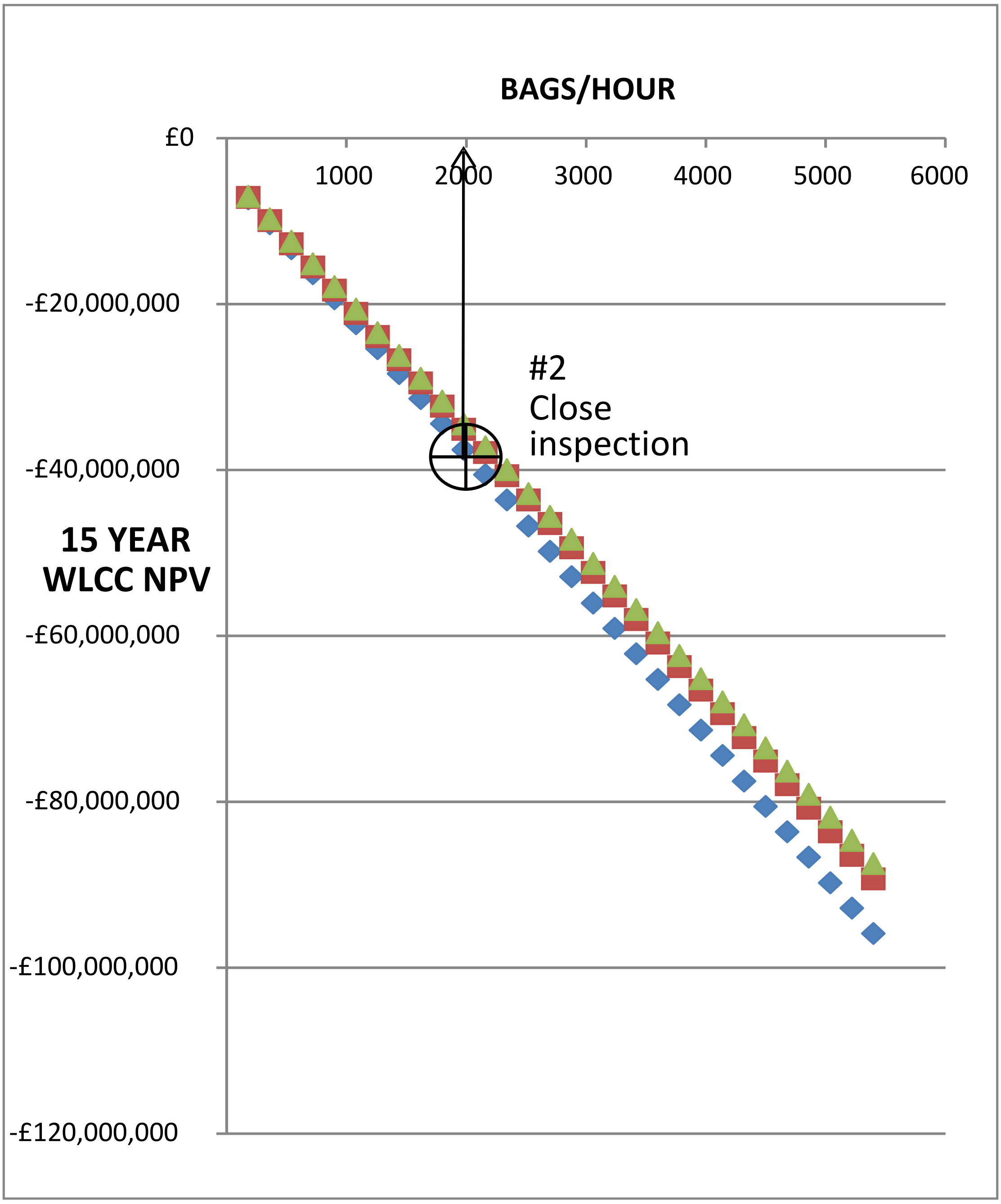
When processing long haul traffic only the introduction of the high CAPEX factor commercially has no affect on the ranking of BHS solutions when compared to the base conditions.

When processing the long haul, and short haul traffic mix the introduction of the high CAPEX factor commercially does not affect the WLCC NPV ranking of any of the of the BHS solution types when compared to the base conditions.

Figure 29: High CAPEX factor scenario: Short haul only[62]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS

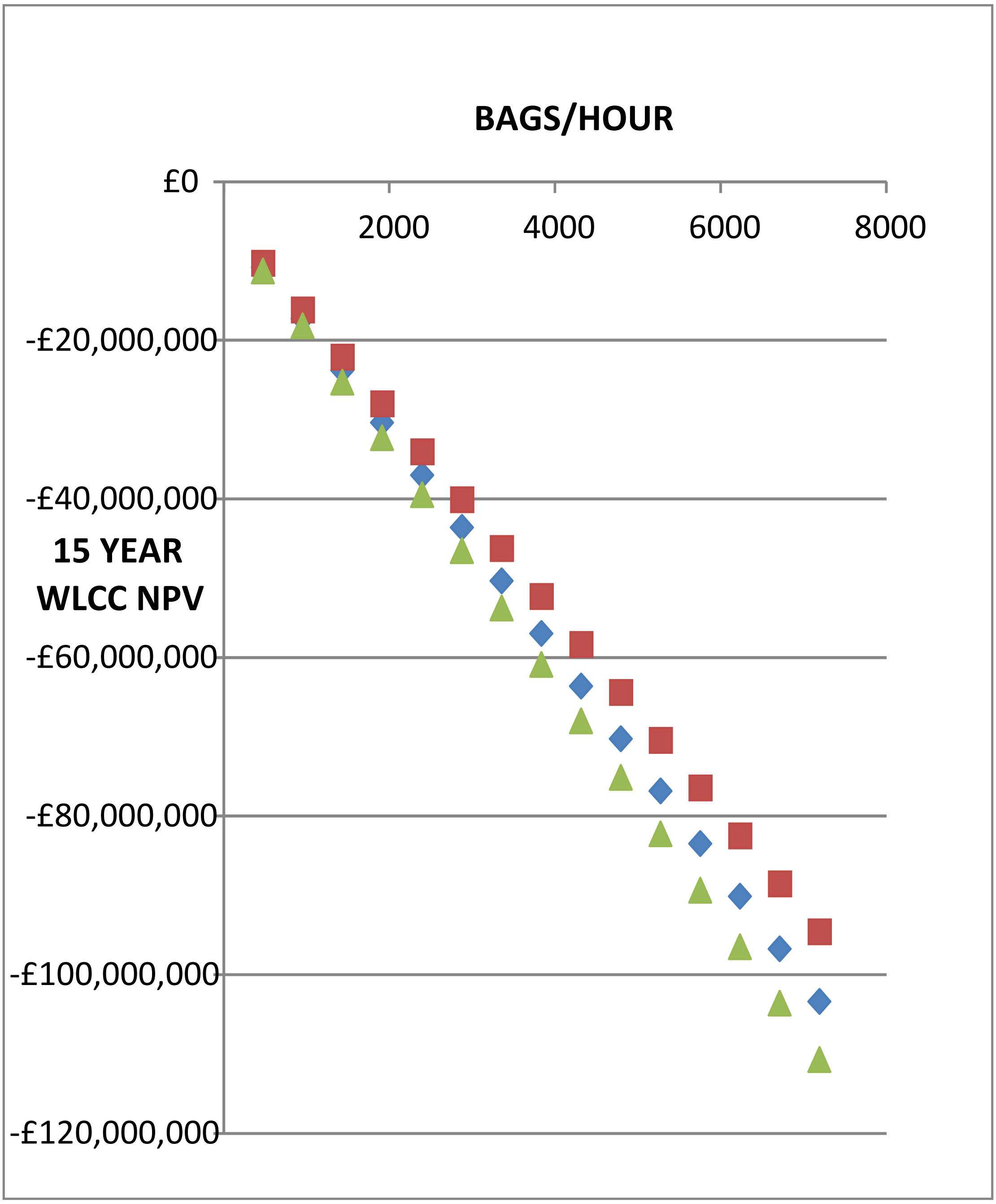


[62] This figure shows the WLCC NPV results using the following input parameters.
110% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 30: High CAPEX factor scenario: Long haul only[63]

Key:

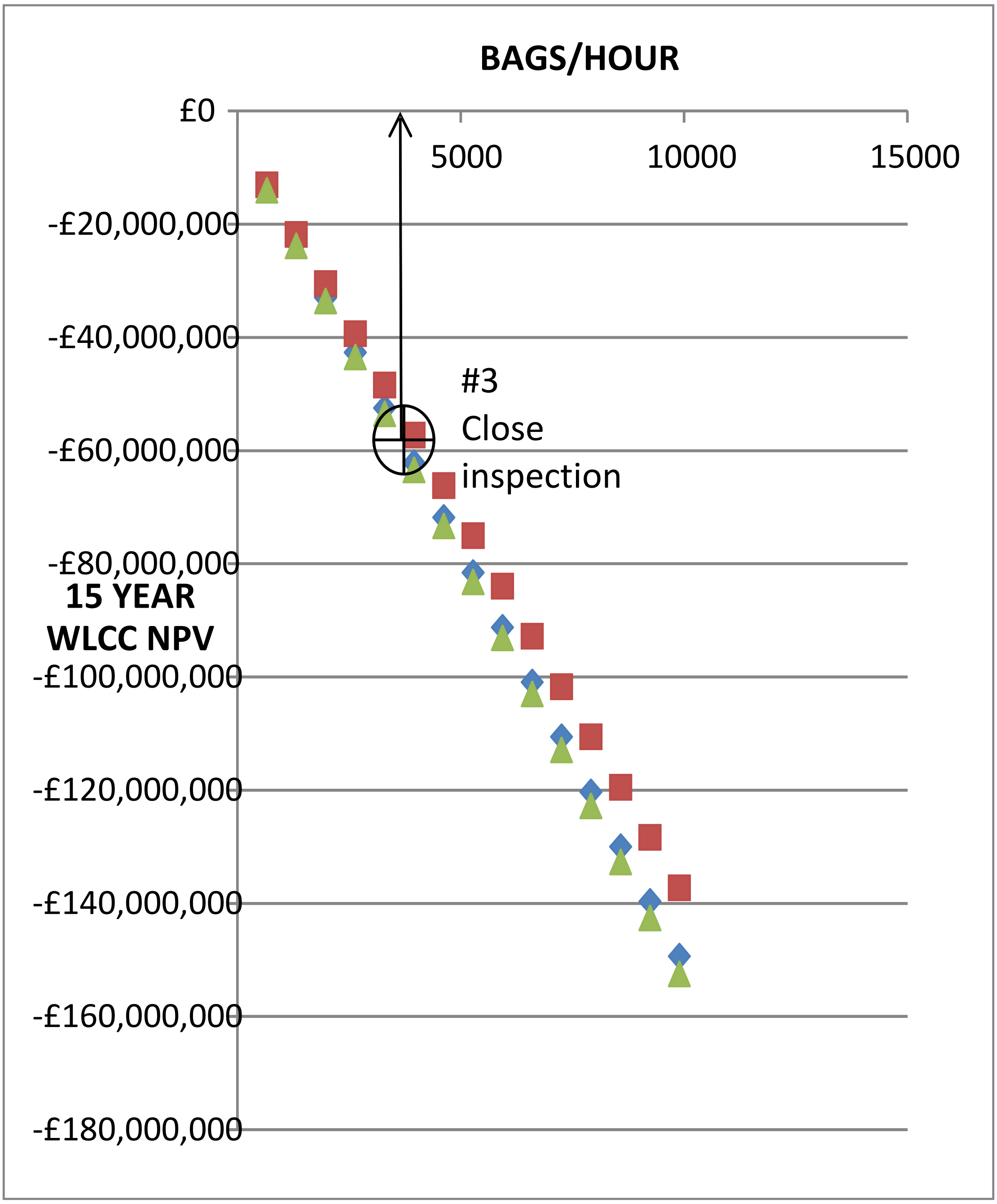
- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



63 This figure shows the WLCC NPV results using the following input parameters.
110% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 31: High CAPEX factor scenario: Long / Short haul mix[64]

Key:
- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



[64] This figure shows the WLCC NPV results using the following input parameters.
110% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

6.7 Sensitivity base medium CAPEX factor results

This section contains the results of the WLCC NPV experiments where the base case CAPEX and OPEX factors have been applied.

6.7.1 Re: Short haul only

With reference to Figure 32 the increased efficiency of the semi-automated BHS, coupled with the average staff costs ensure a narrow financial margin between semi and manual BHS solution WLCC NPVs.

It can be seen that the fully automatic BHS solution is the most expensive, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the second cheapest from a WLCC NPV perspective.

6.7.2 Re: Long haul only

With regards to Figure 33 it can be seen that the semi-automated build lends itself to long haul processing. This is due to the operational ability to process demand over the extended long haul flight open period. The fully automated BHS solution can also efficiently process long haul flights using robotic build equipment albeit with its higher CAPEX.

It can be seen that the fully automatic BHS solution is second cheapest, the semi-automatic BHS solution is the cheapest and the manual BHS solution is the most expensive from a from a WLCC NPV perspective.

6.7.3 Re: Long haul short haul mix

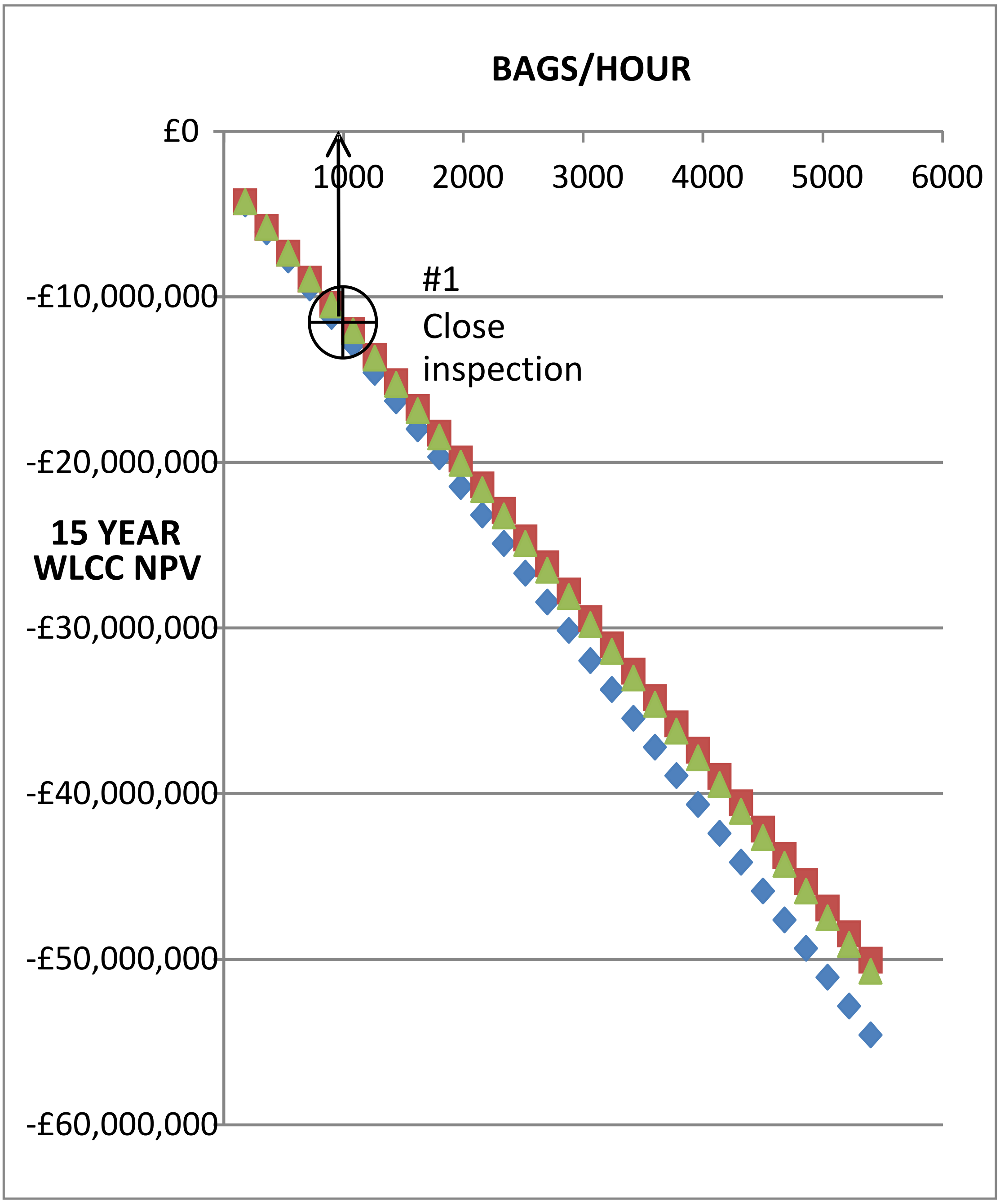
Inspection of Figure 34 shows that when a mix of long haul, and short haul flights are used in the flight schedule the semi-automated build particularly shows a lower WLCC NPV by a significant margin. This is due to the ability to process demand over the longer long haul flight open period, and the higher processing rate and relatively low CAPEX of the RTT units within the semi-automated BHS. With reference to the results seen in Appendix H, this is also due to the need to provide less BHS building area, and the need for less staff, leading to a lower OPEX.

It can be seen that the fully automatic BHS solution is second cheapest, the semi-automatic BHS solution is the cheapest and the manual BHS solution is the most expensive from a WLCC NPV perspective.

Under base case input parameter conditions it can be seen from Figure 32, Figure 33, and Figure 34, that the semi-automated BHS is the cheapest solution. The processing of long haul baggage increases the WLCC NPV differential between manual and fully and semi-automated BHSs.

Figure 32: BASE reference mid range scenario: Short haul only[65]

Key:
- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS

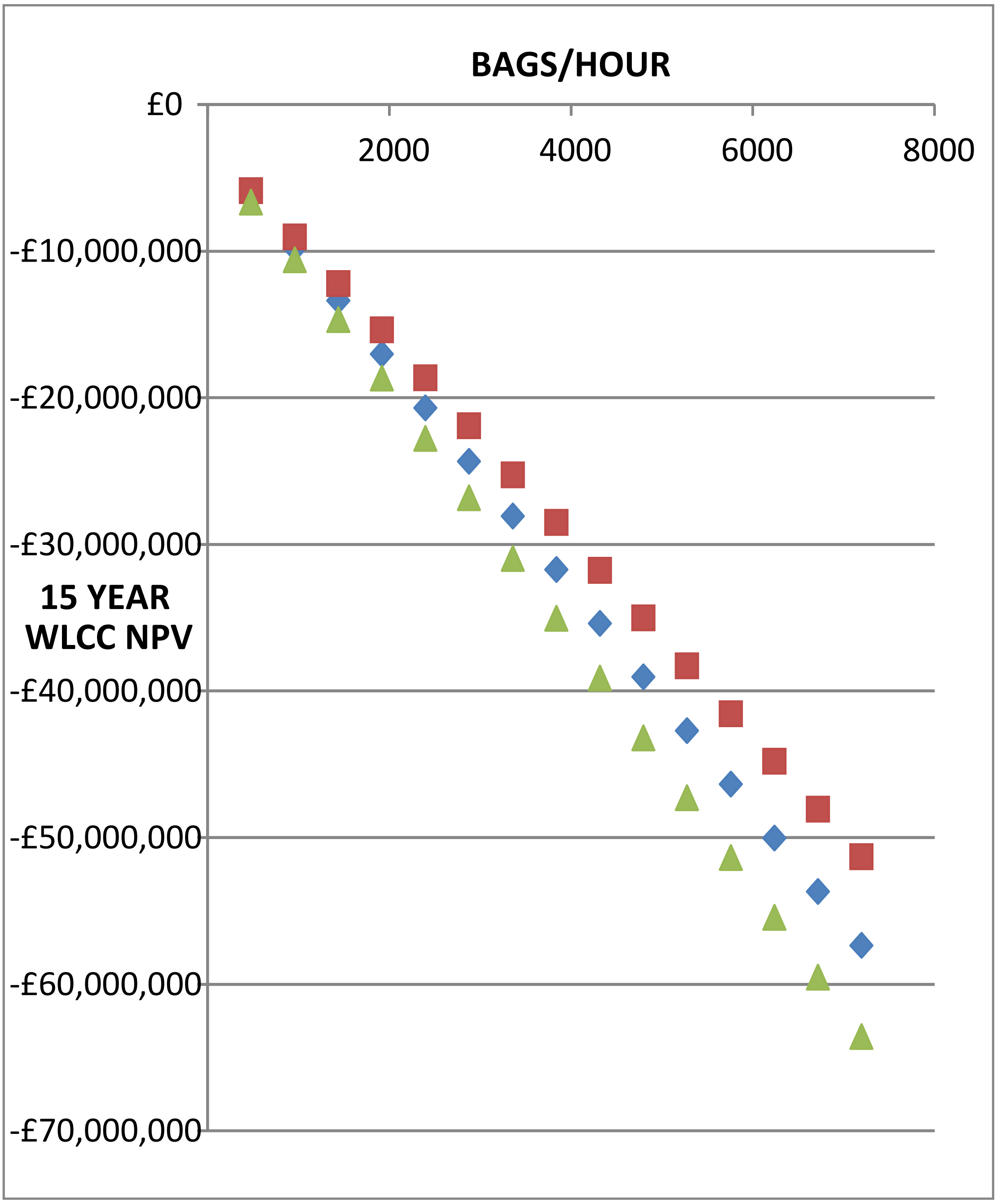


[65] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 33: BASE reference mid range scenario: Long haul only[66]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS

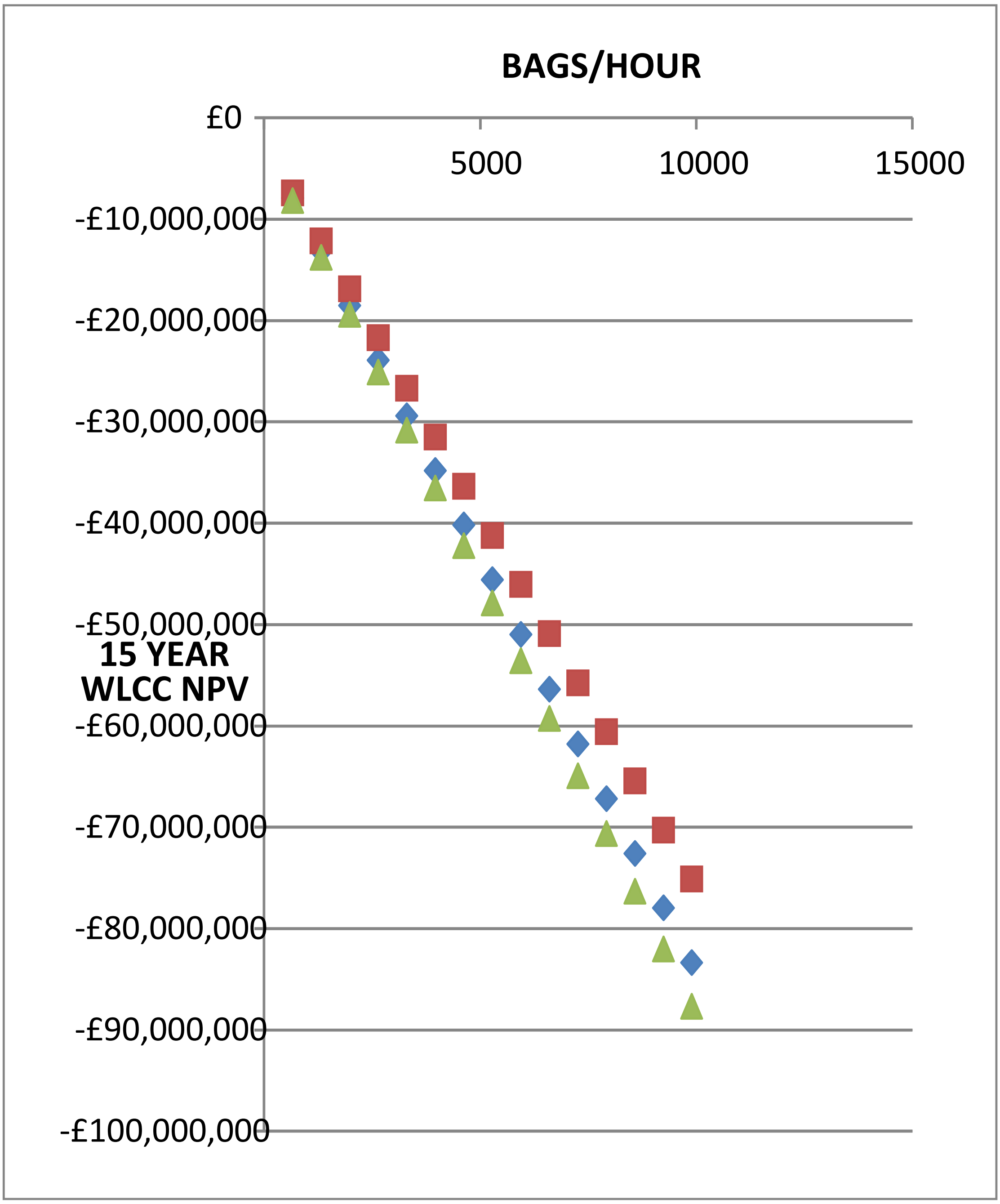


66 This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 34: BASE reference mid range scenario: Long / short haul mix[67]

Key:

Fully Automatic BHS
Semi-Automatic BHS
Manual BHS



[67] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

6.8 Sensitivity low CAPEX factor results

This section contains the results of the WLCC NPV experiments where the low CAPEX and OPEX factors have been applied.

6.8.1 Re: Short haul only

Figure 35 shows that with a low CAPEX factor the cost of the semi-automatic build equipment present with the semi-automated BHS can be recovered through OPEX savings of this equipment. With reference to the results seen in Appendix H it should be noted that manual BHS solution occupies significantly more baggage hall area than semi and the fully automated BHS solutions.

It can be seen that the fully automatic BHS solution is the most expensive, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the second cheapest from a WLCC NPV perspective.

6.8.2 Re: Long haul only

Figure 36 shows that when processing a long haul flight schedule only with a low CAPEX factor the cost of the semi-automatic build equipment present with the semi-automated BHS, and to a lesser extent the CAPEX of the fully automatic build equipment, can be recovered through OPEX savings of this equipment. With reference to the results seen in Appendix H it should be noted that manual BHS solution occupies significantly more baggage hall area than semi and the fully automated BHS solutions.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

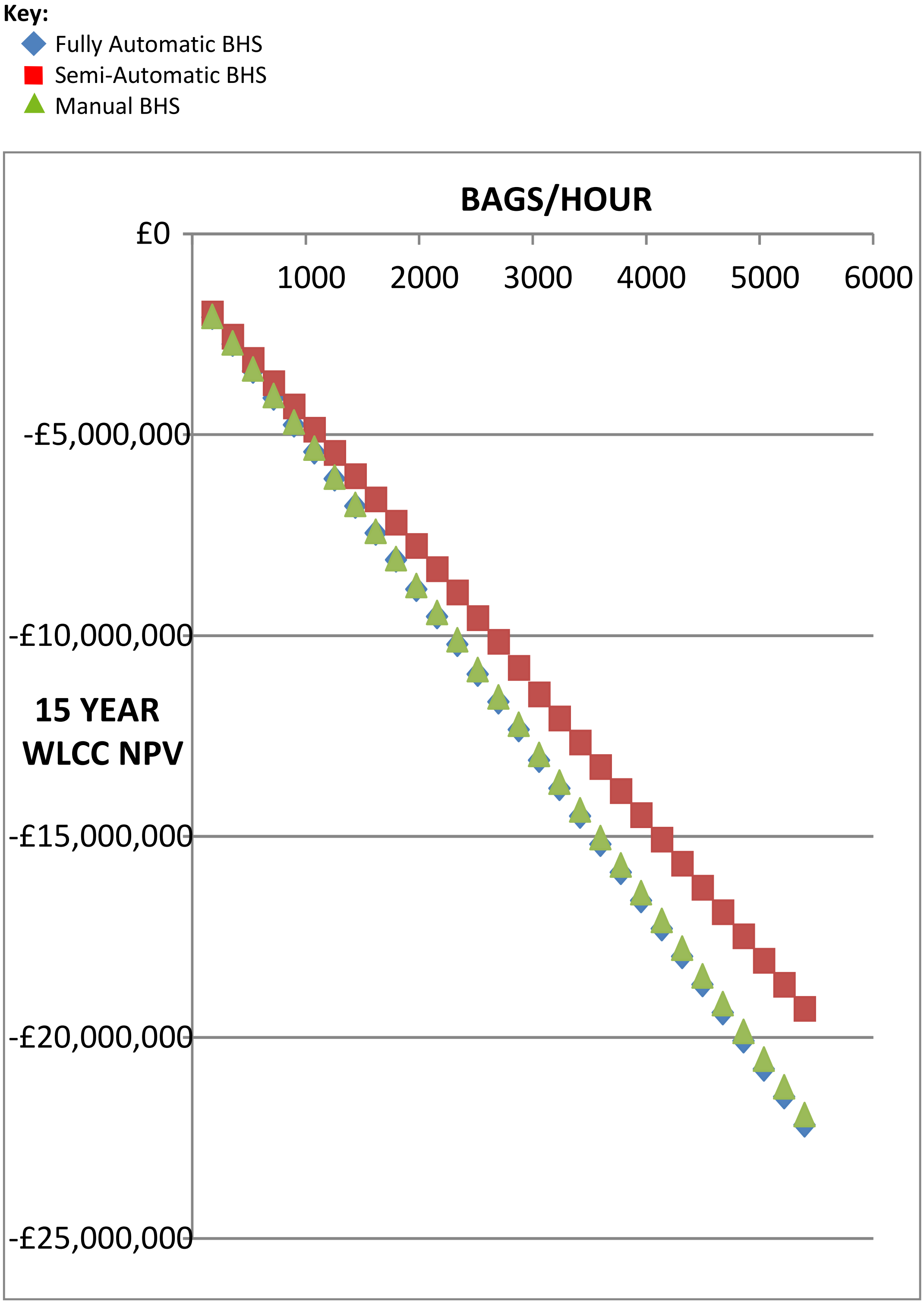
6.8.3 Re: Long haul short haul mix

Figure 37 shows that when processing a long haul, and short haul mix flight schedule, with a low CAPEX factor the cost of the semi-automatic build equipment present with the semi-automated BHS, and to a lesser extent the CAPEX of the fully automatic build equipment, can be recovered through OPEX savings of this equipment. With reference to the results seen in Appendix H it should be noted that manual BHS solution occupies significantly more baggage hall area than semi and the fully automated BHS solutions.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective. Under low CAPEX input parameter conditions it can be seen from Figure 35, Figure 36 and Figure 37 that the semi-automated BHS is always the cheapest solution.

The fully automated BHS solution, and the manual BHS solution switch ranking, in terms of coming second and third cheapest from a WLCC NPV perspective, dependent upon whether or not they process long haul flights. The processing of long haul baggage generally demotes the ranking of manual BHS solution with a low CAPEX factor.

Figure 35: Low CAPEX factor scenario: Short haul only[68]

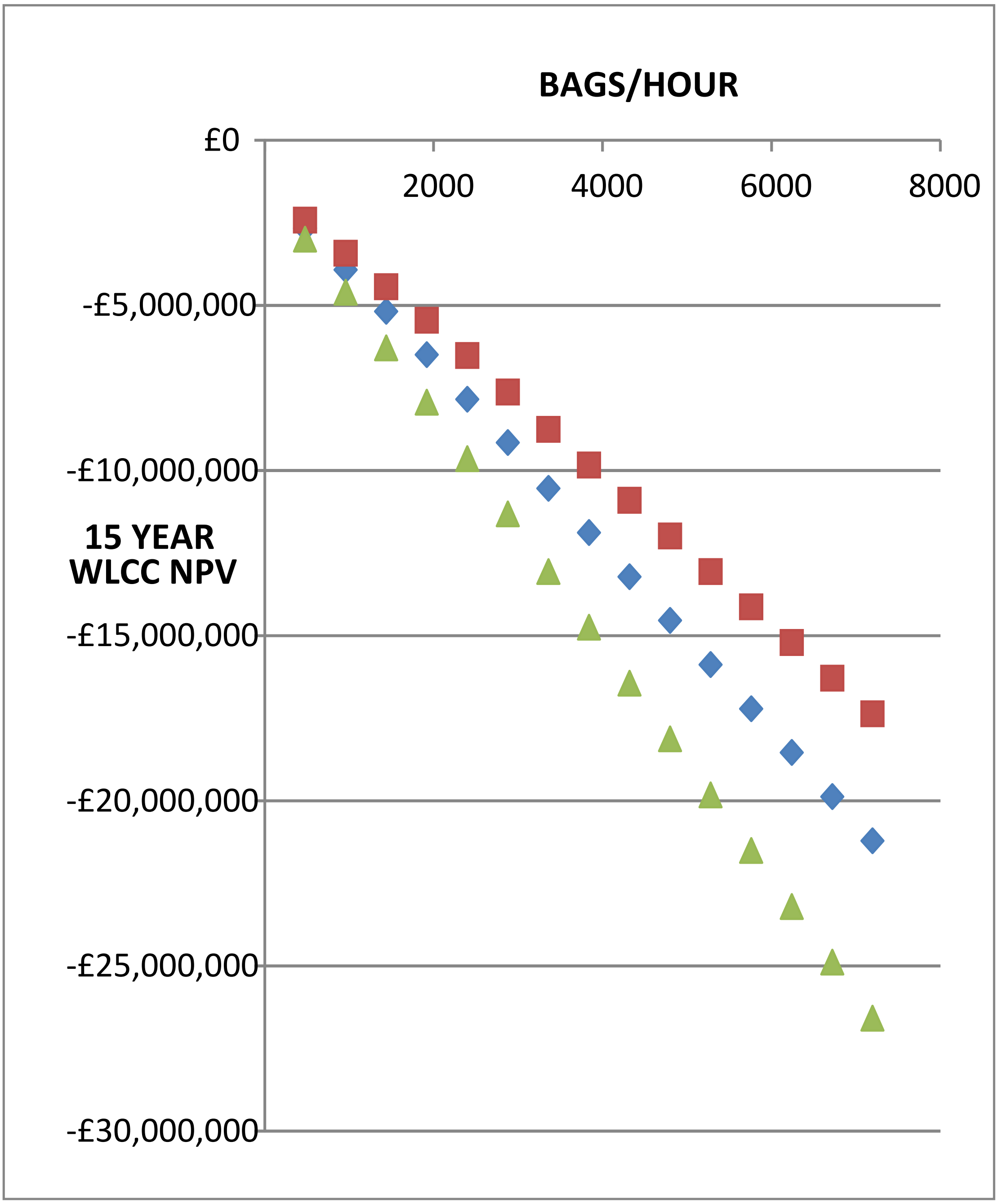


68 This figure shows the WLCC NPV results using the following input parameters.
19% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 36: Low CAPEX factor scenario: Long haul only[69]

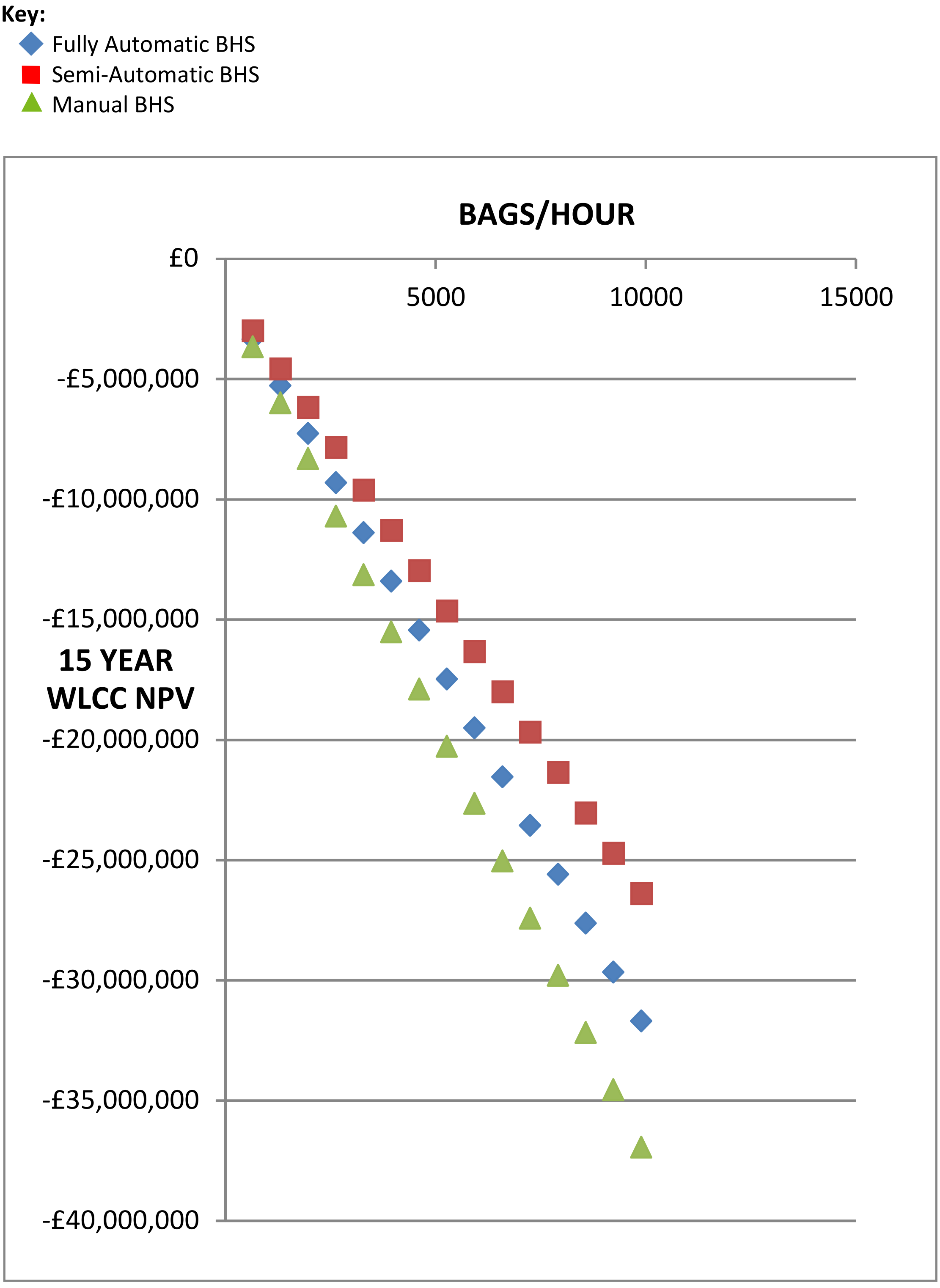
Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



[69] This figure shows the WLCC NPV results using the following input parameters.
19% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 37: Low CAPEX factor scenario: Long / short haul mix[70]



70 This figure shows the WLCC NPV results using the following input parameters.
19% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

6.9 Sensitivity high OPEX factor results

This section contains the results of the WLCC NPV experiments where the high OPEX factor has been applied.

6.9.1 Re: Short haul only

Figure 38 shows that when processing short haul flights only with the High OPEX factor applied this has no impact on the manual WLCC NPV when compared to the base factor results.

With reference to the results provided in Appendix H it can be seen that manual BHS solutions that process short haul occupy less area than the alternative BHS types, but require significantly more staff than the fully, and semi-automated BHS solutions.

It can be seen that the fully automatic BHS solution is the most expensive, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the second cheapest from a WLCC NPV perspective.

6.9.2 Re: Long haul only

It can be seen in Figure 39 that when processing long haul flights only, and with the high OPEX factor applied this has a negative impact upon the manual BHS WLCC NPV ranking. The semi-automated and fully automatic build lends itself to long haul processing and this promotes the ranking of both fully and semi-automated BHS from a WLCC NPV perspective.

It can be seen in the results provided in Appendix H that the manual BHS solutions occupy significantly more area, and require more staff, than fully and semi-automated BHSs.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

6.9.3 Re: Long haul short haul mix

Figure 40 shows that when processing both long haul and short flights with the high OPEX factor applied this has a negative impact (demotes its financial ranking) on the manual WLCC NPV.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

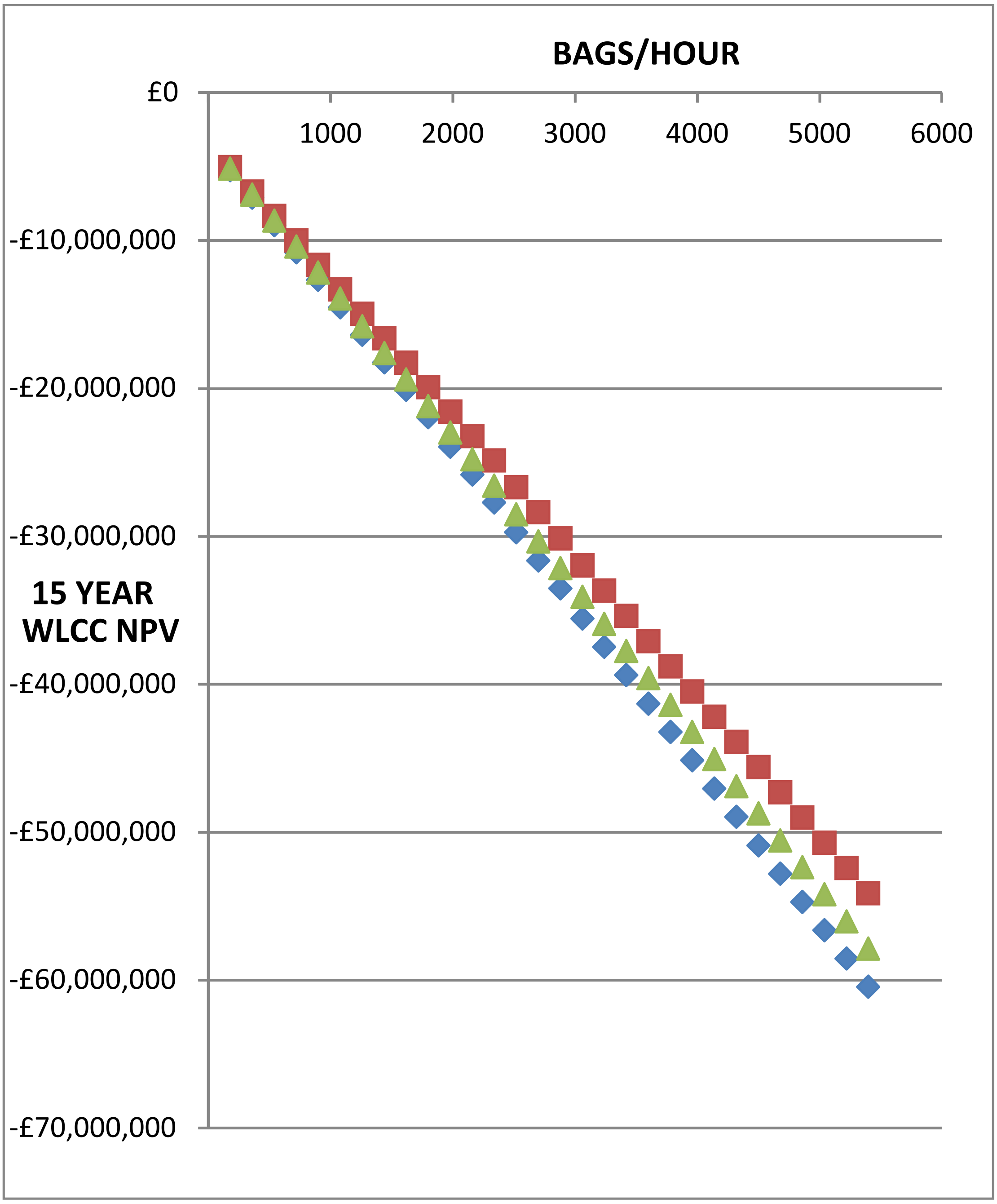
When the high OPEX input factor is applied, the graphed results of Figure 38,

Figure 39, and Figure 40 show that the semi-automated BHSs are always the cheapest solution from a WLCC NPV perspective. The financial ranking of manual BHS solutions gets demoted to third most cost effective when long haul flights are processed.

Figure 38: High OPEX factor scenario: Short haul only[71]

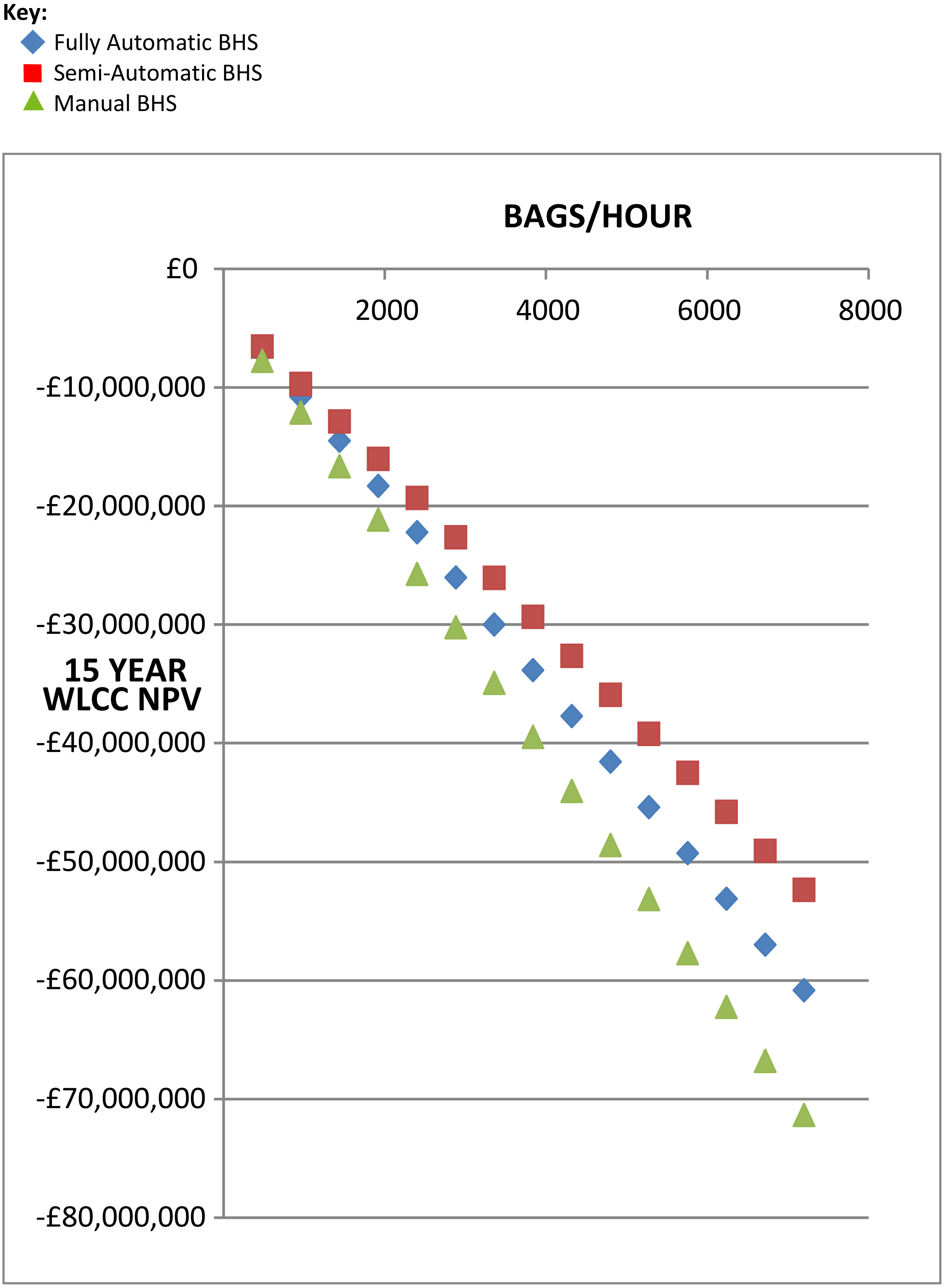
Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



[71] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
110% OPEX factor applied
3% inflation applied
2bags/min loading rate

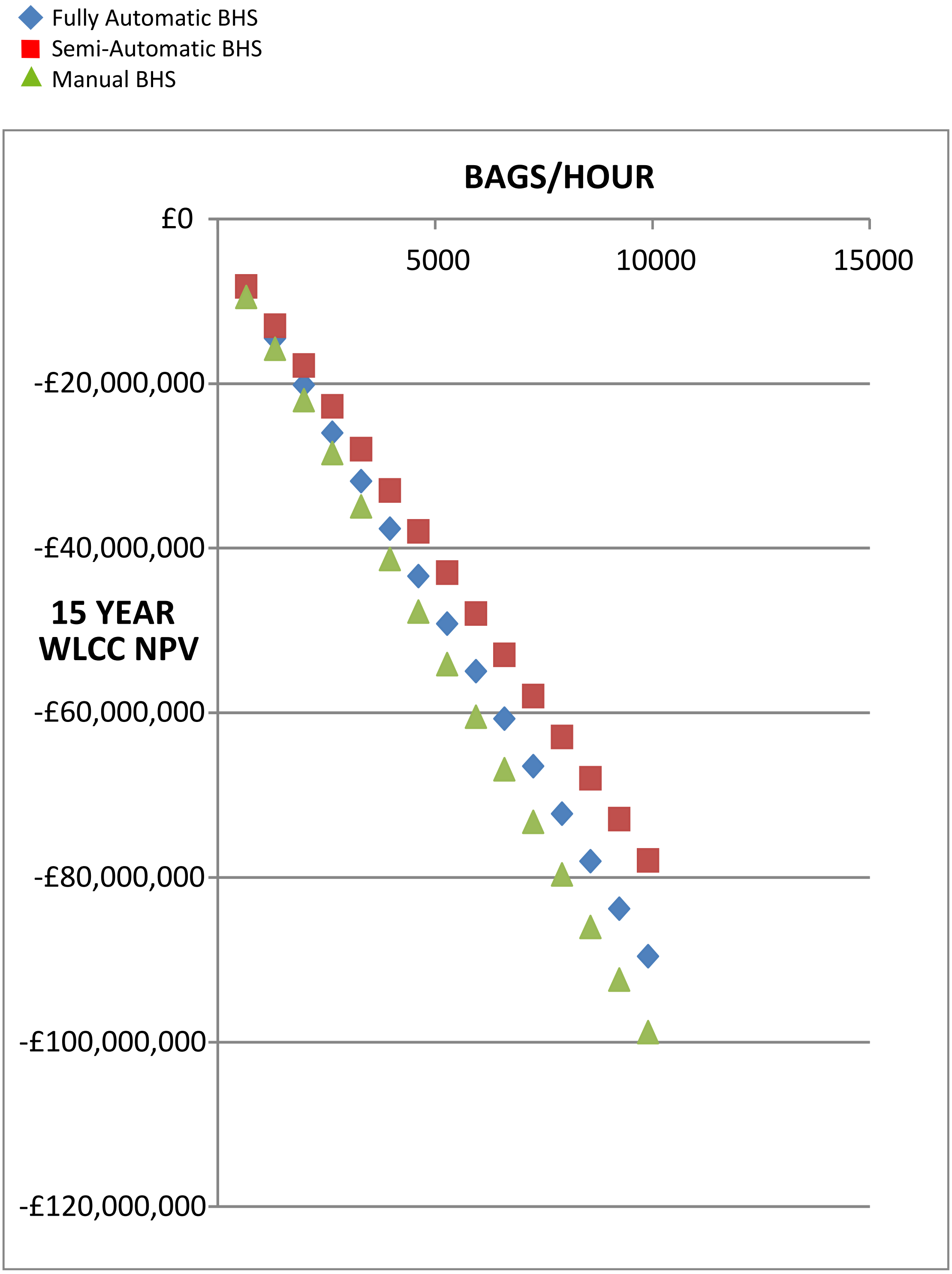
Figure 39: High OPEX factor scenario: Long haul only[72]



[72] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
110% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 40: High OPEX factor scenario: Long / short haul mix[73]

Key:



[73] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
110% OPEX factor applied
3% inflation applied
2bags/min loading rate

6.10 Sensitivity low OPEX factor results

This section contains the results of the WLCC NPV experiments where the low OPEX factor has been applied.

6.10.1 Re: Short haul only

It can be seen from Figure 41 that when short haul traffic is processed by the three types of BHS solution, with a low OPEX factor applied, this has a significant positive affect on the WLCC NPV financial ranking of the manual BHS solution.

It can be seen that the fully automatic BHS solution is the most expensive, the semi-automatic BHS solution is the second cheapest, and the manual BHS solution is the cheapest from a WLCC NPV perspective.

6.10.2 Re: Long haul only

Figure 42 shows that when long haul traffic is processed, with a low OPEX factor applied, this has a major impact on the manual WLCC NPV financial ranking. It demotes its financial ranking from first place to third place when compared to the results seen in Figure 41.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

6.10.3 Re: Long haul short haul mix

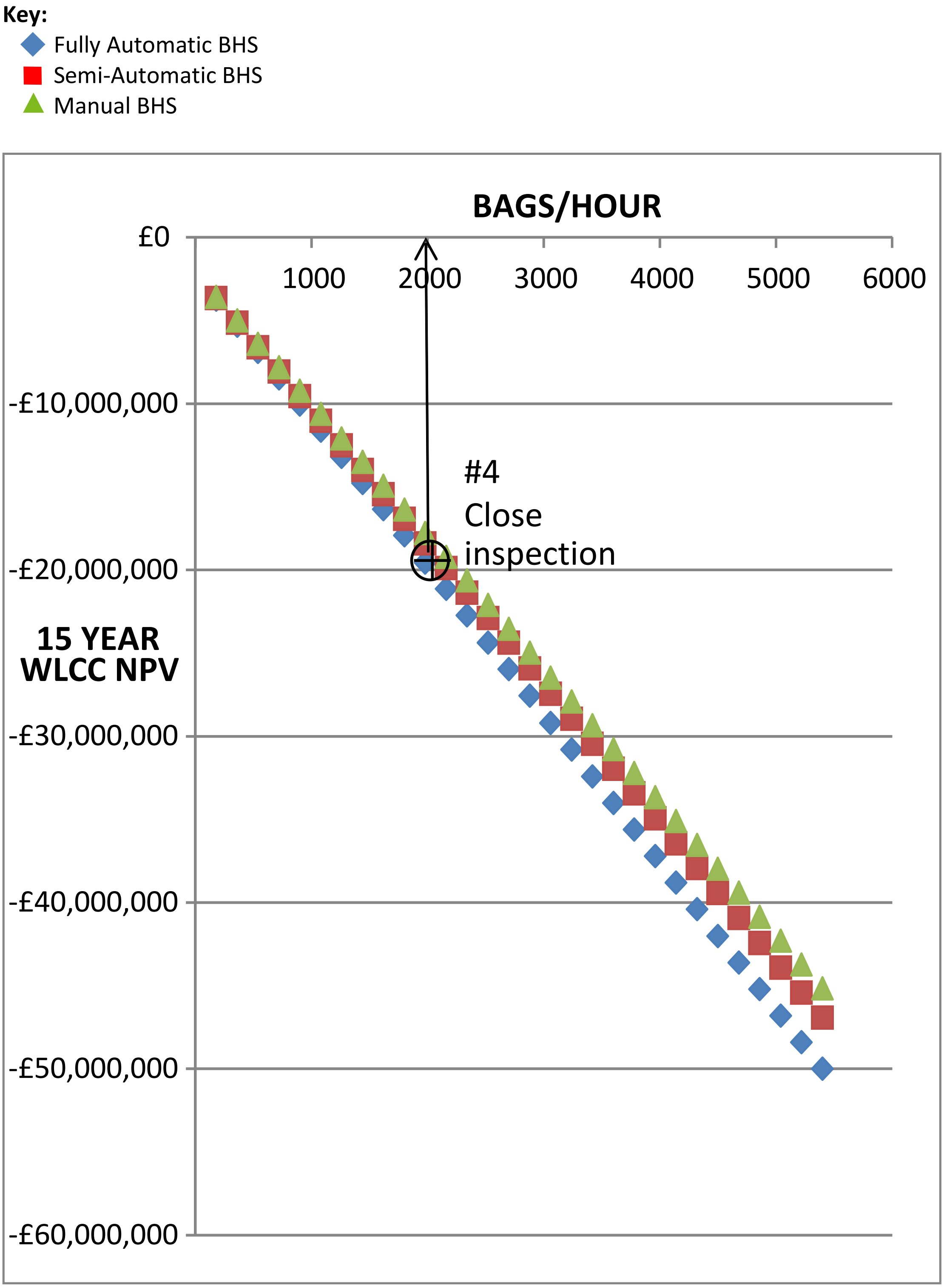
It should be noted from Figure 43 that when combined short haul and long haul traffic are processed with a low OPEX factor applied, this significantly changes the financial ranking of the manual BHS. This is due to the cost reduction affect associated within the staff costs which are comparatively greater with this BHS solution.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

When the low OPEX input factor is applied, the graphed results of Figure 41, Figure 42, and Figure 43 show that when processing either (i) long haul traffic or (ii) short haul / long haul mixed traffic the semi-automated BHSs are the cheapest solution from a WLCC NPV perspective.

The financial ranking of the manual BHS solutions gets significantly promoted to first place when only short haul traffic is processed.

Figure 41: Low OPEX factor scenario: short haul only[74]

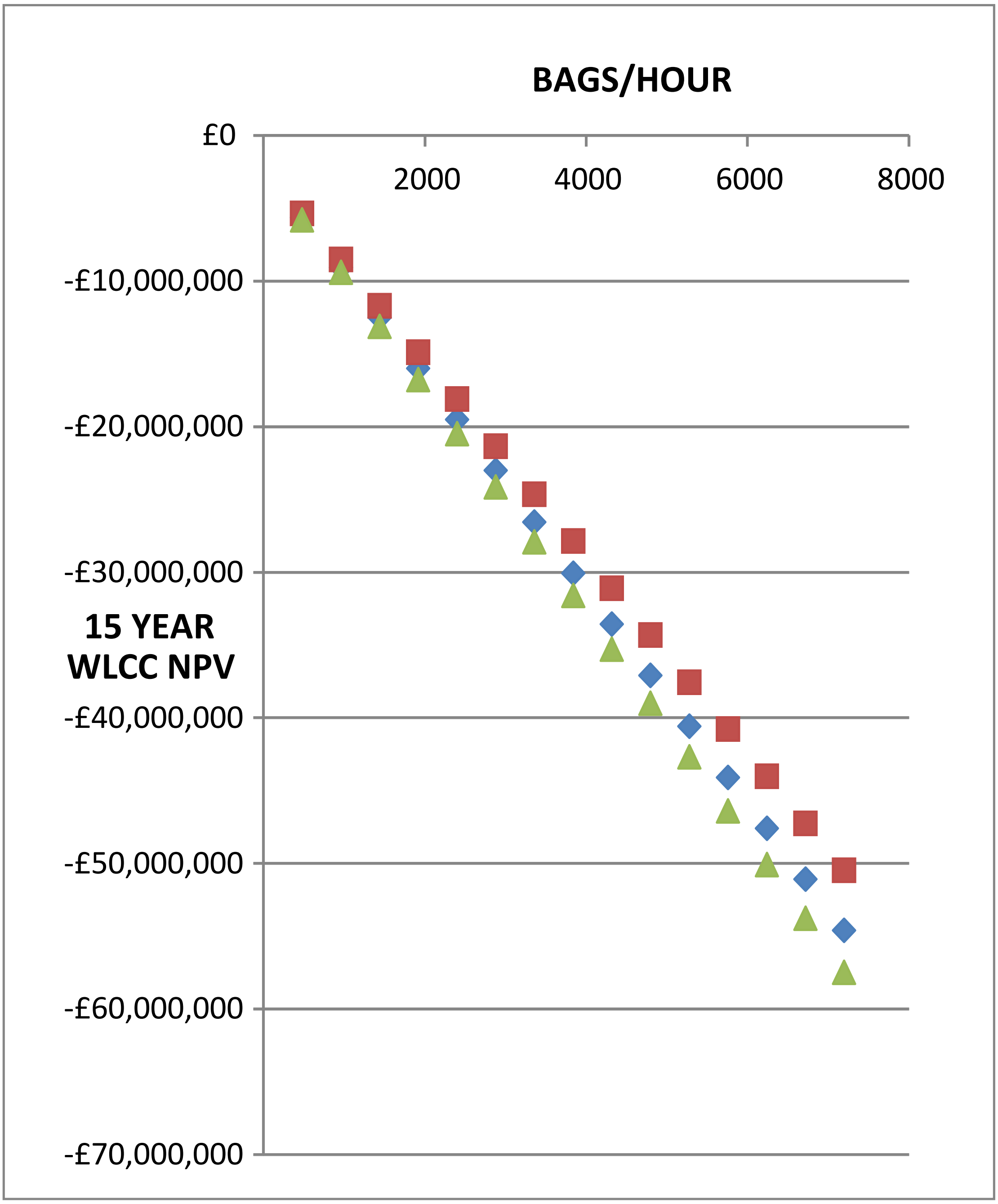


[74] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
19% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 42: Low OPEX factor scenario: Long haul only[75]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS

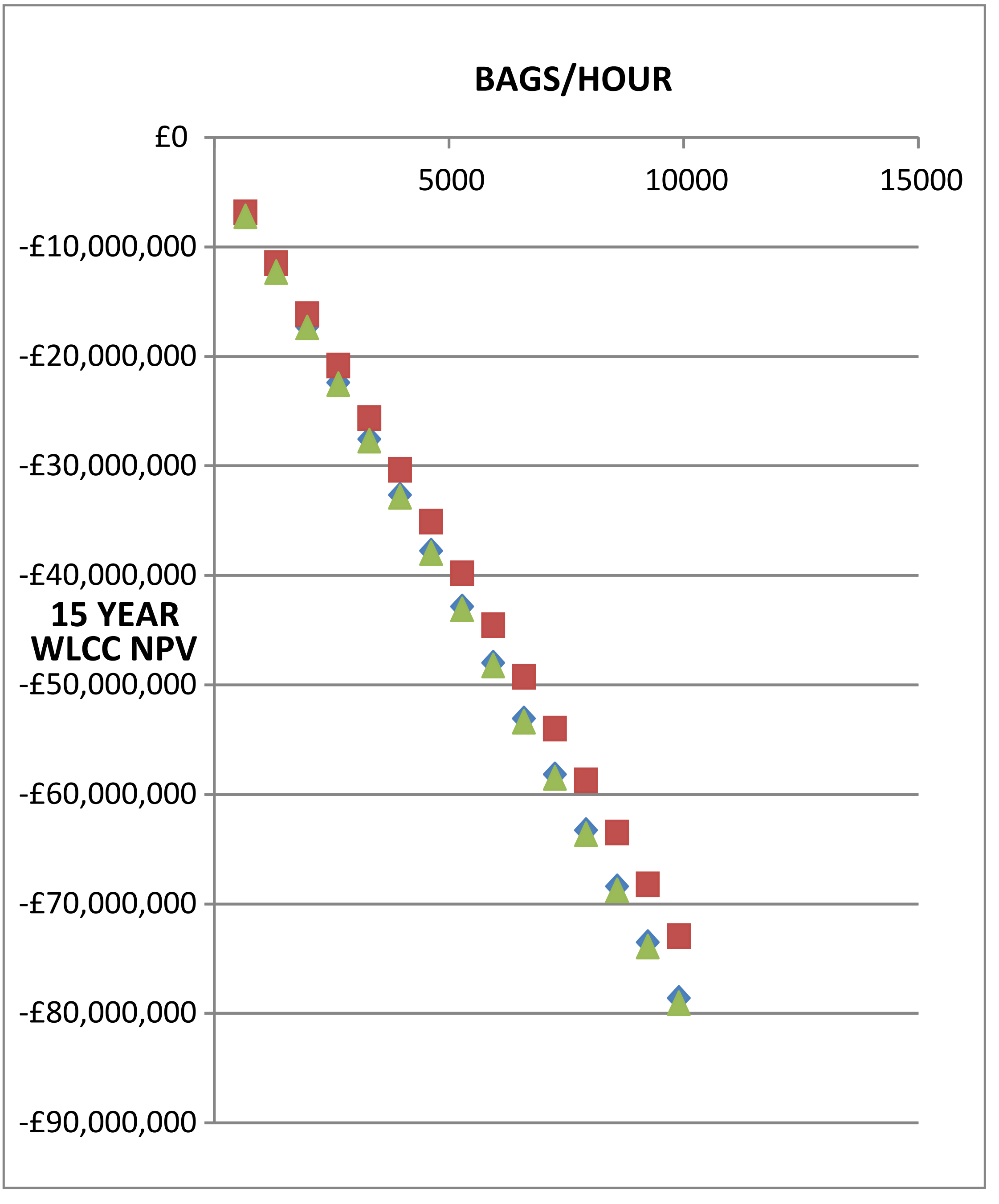


[75] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
19% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 43: Low OPEX factor scenario: Long haul short haul mix[76]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



[76] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
19% OPEX factor applied
3% inflation applied
2bags/min loading rate

6.11 Sensitivity high inflation rate results

This section contains the results of the WLCC NPV experiments where the high inflation factor has been applied.

6.11.1 Re: Short haul only

Figure 44 shows that when processing short haul traffic only with a high inflation factor applied to the financial assessment the WLCC NPV ranking of the manual BHS solution gets promoted to second cheapest.

It can be seen that the fully automatic BHS solution is the most expensive, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the second cheapest from a WLCC NPV perspective.

6.11.2 Re: Long haul only

With reference to Figure 45 it can be seen that when processing long haul traffic, and when the high inflation factor is applied the semi-automatic BHS solutions maintain their first place WLCC NPV financial ranking.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

6.11.3 Re: Long haul short haul mix

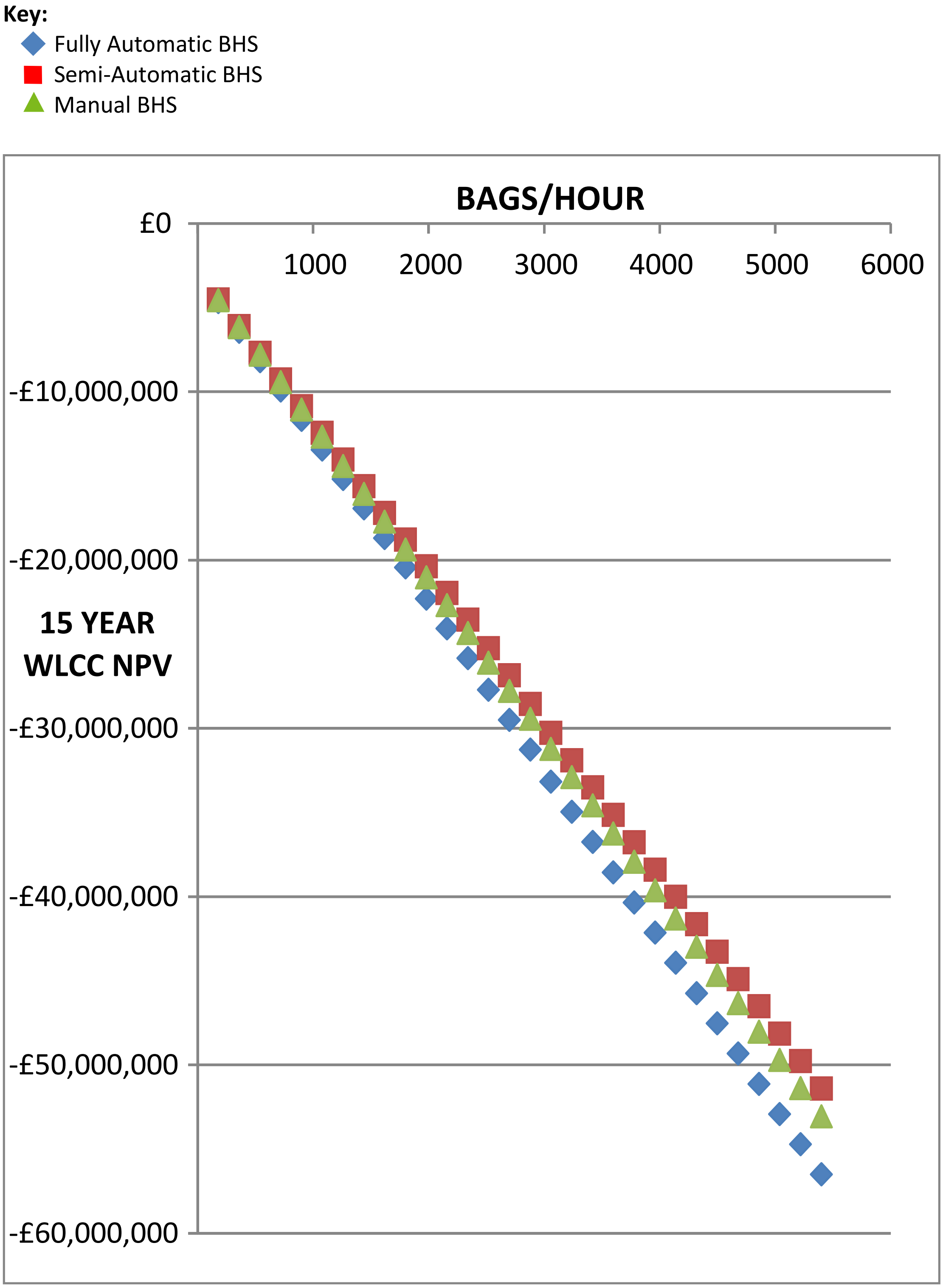
Figure 46 shows that when processing both short haul and long haul traffic, and when the high inflation factor is applied the semi-automatic BHS solutions again maintain their first place WLCC NPV financial ranking.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

When the high inflation input factor is applied, the graphed results of Figure 44, Figure 45, and Figure 46 show that when processing either: (i) short haul, (ii) long haul traffic, or (iii) short haul / long haul mixed traffic the semi-automated BHSs are the cheapest solution from a WLCC NPV perspective.

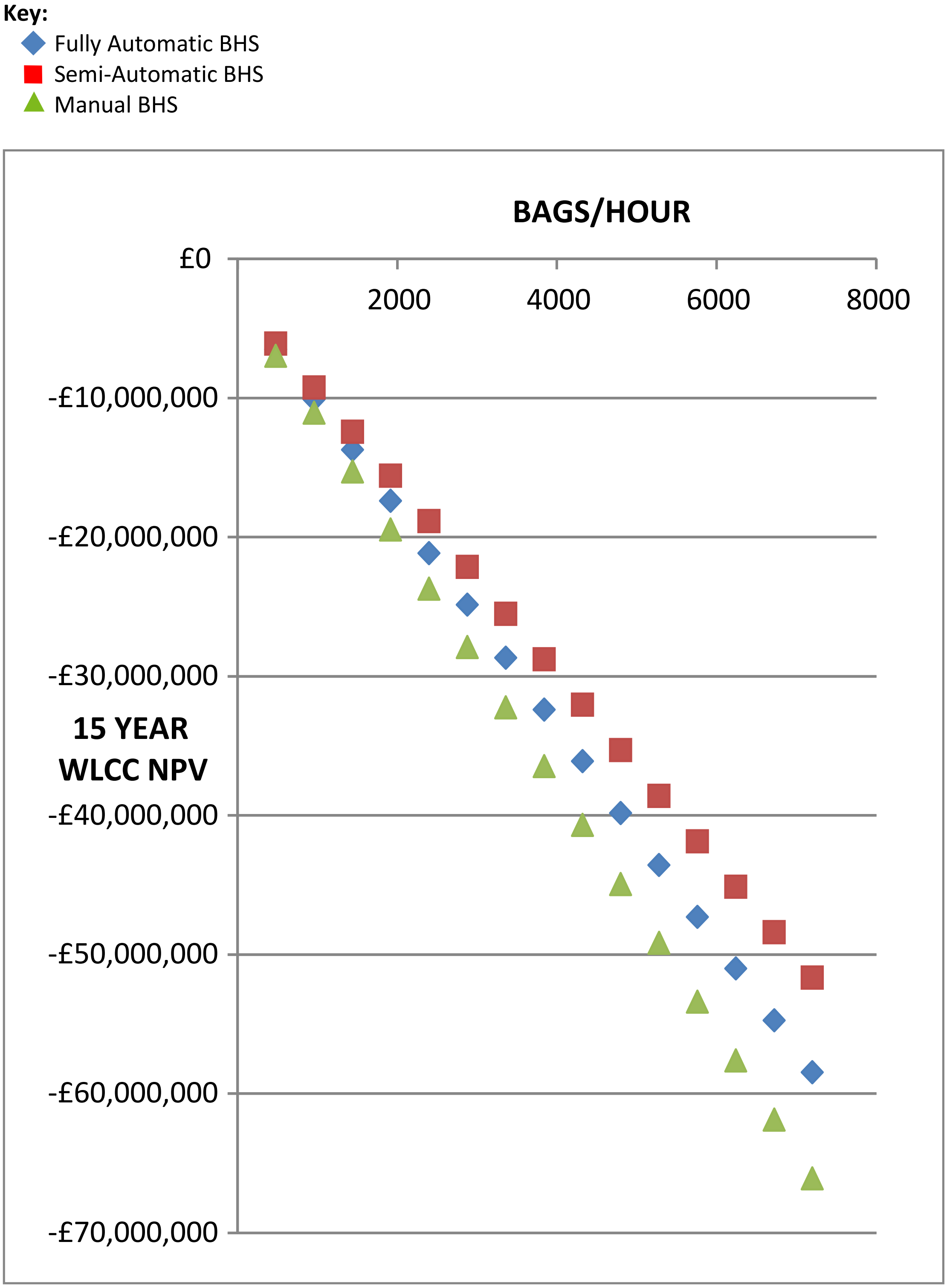
The financial ranking of the manual BHS solutions gets promoted to second place when only short haul traffic is processed.

Figure 44: High inflation rate scenario: Short haul only[77]



[77] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
7% inflation applied
2bags/min loading rate

Figure 45: High inflation rate scenario: Long haul only[78]



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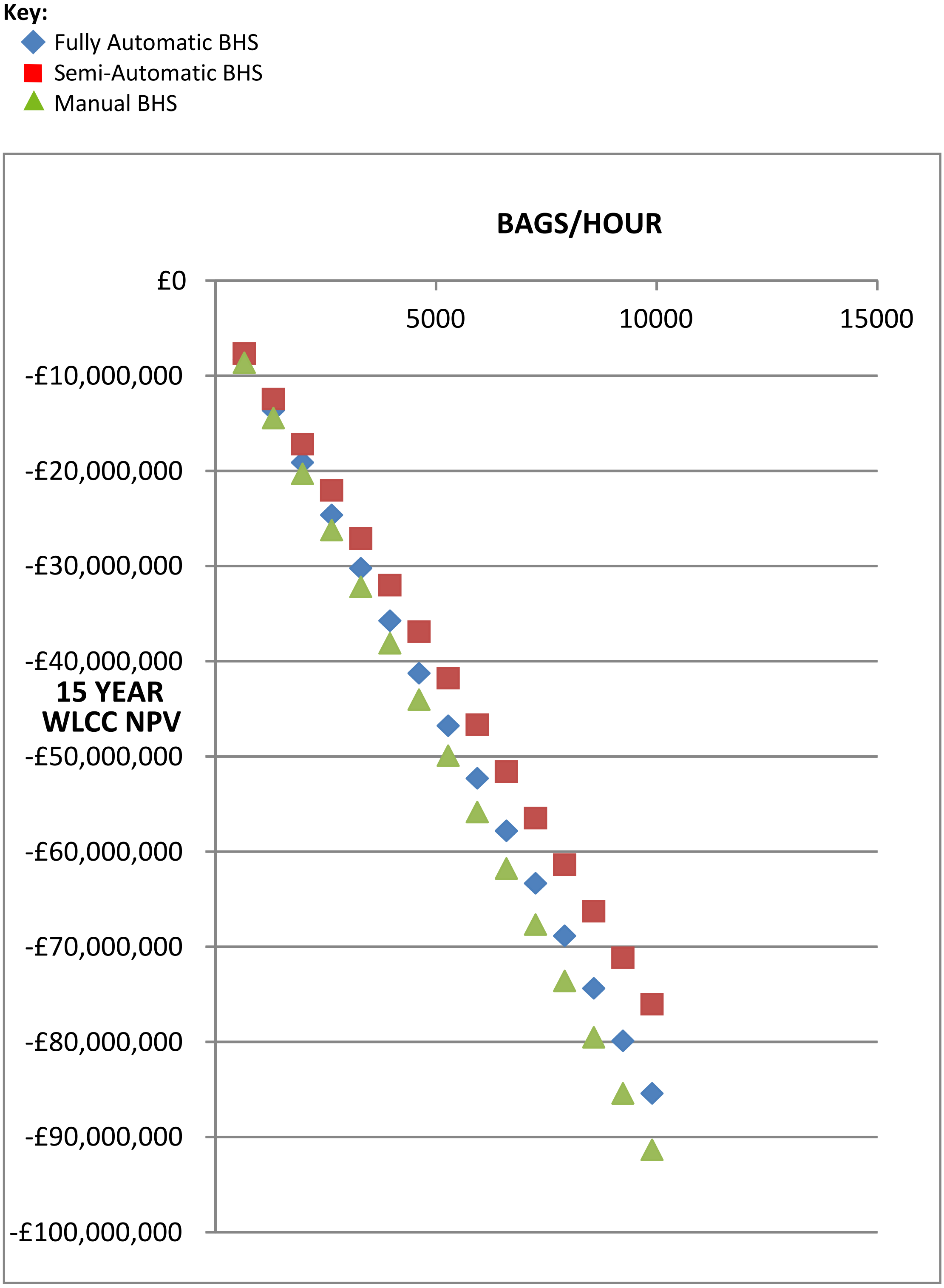
[78] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
7% inflation applied
2bags/min loading rate

Figure 46: High inflation rate scenario: Short haul / long haul mix[79]



[79] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
7% inflation applied
2bags/min loading rate

6.12 Sensitivity low inflation rate results

This section contains the results of the WLCC NPV experiments where the low inflation factor has been applied.

6.12.1 Re: Short haul only

Figure 47 shows that when processing short haul traffic only, and when the low inflation factor has been applied, the manual BHS solutions predominantly maintain their position as the second cheapest BHS as per the reference base condition seen in Figure 32. When the low inflation factor is applied to BHSs processing upto 1080 bags per hour of short haul traffic the manual BHS solutions are ranked cheapest.

It can be seen that the fully automatic BHS solution is the most expensive, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the second cheapest from a WLCC NPV perspective. In this scenario the low inflation rate reduces the WLCC NPV cost of the additional staff that must be present with the more staff intensive manual BHS solutions.

6.12.2 Re: Long haul only

With respect to Figure 48 it can be seen that, when the low inflation factor is applied to BHSs processing only long haul traffic, the ranking of the fully automated BHSs, semi-automated BHS, and manual BHSs are unchanged when compared to the base condition seen in Figure 33.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

6.12.3 Re: Long haul short haul mix

It can be seen in Figure 49 that when the low inflation factor is applied to the BHSs processing both short haul, long haul, and long haul traffic this has no impact when compared to the WLCC NPV base case rankings denoted in Figure 34.

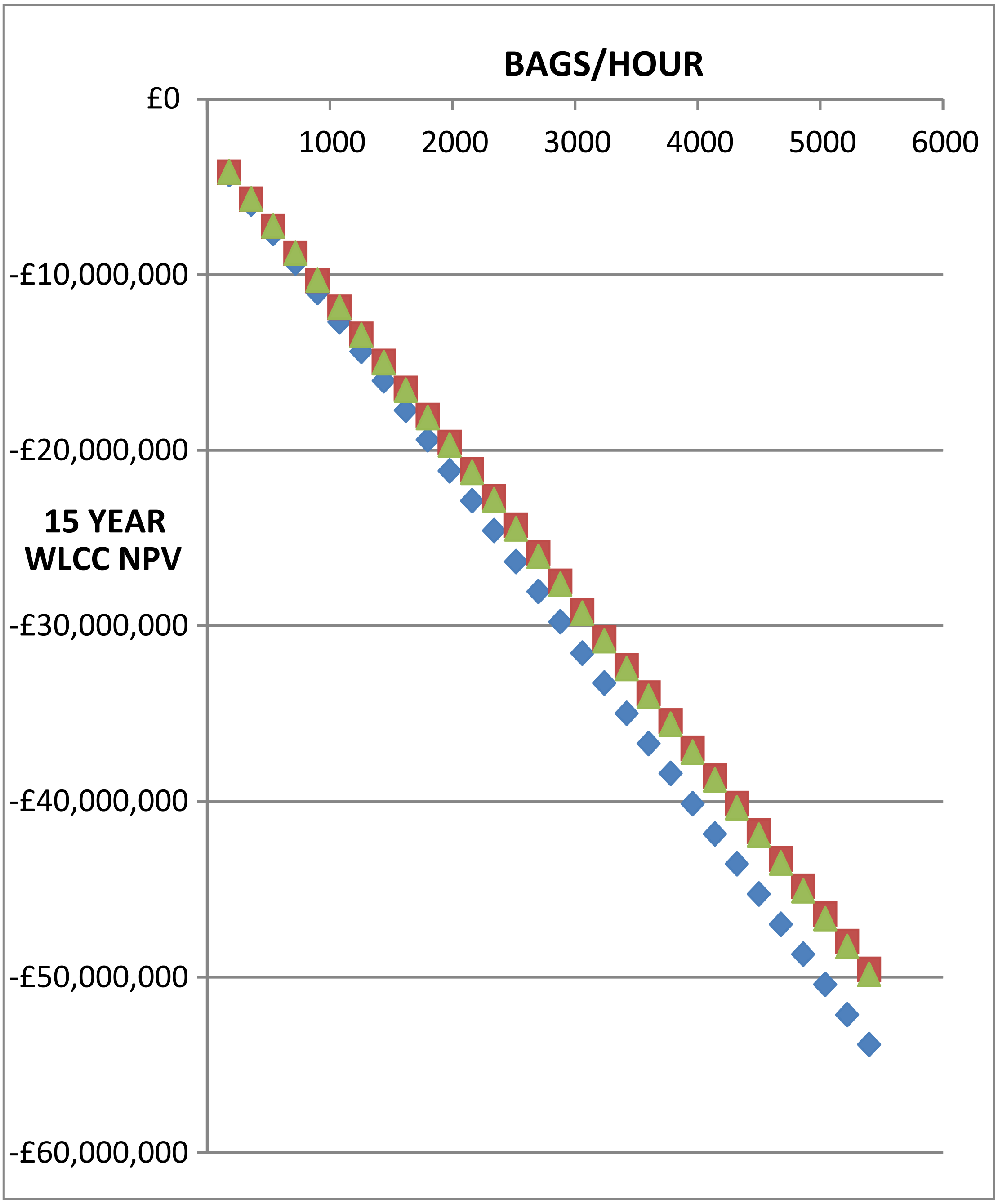
It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

When the low inflation input factor is applied, the graphed results of Figure 47, Figure 48, and Figure 49, shows that when processing either (i) short haul, (ii) long haul or, (iii) short haul / long haul mixed traffic, the semi-automated BHSs are generally and predominantly the cheapest solution from a WLCC NPV perspective.

Figure 47: Low inflation rate scenario: Short haul only[80]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS

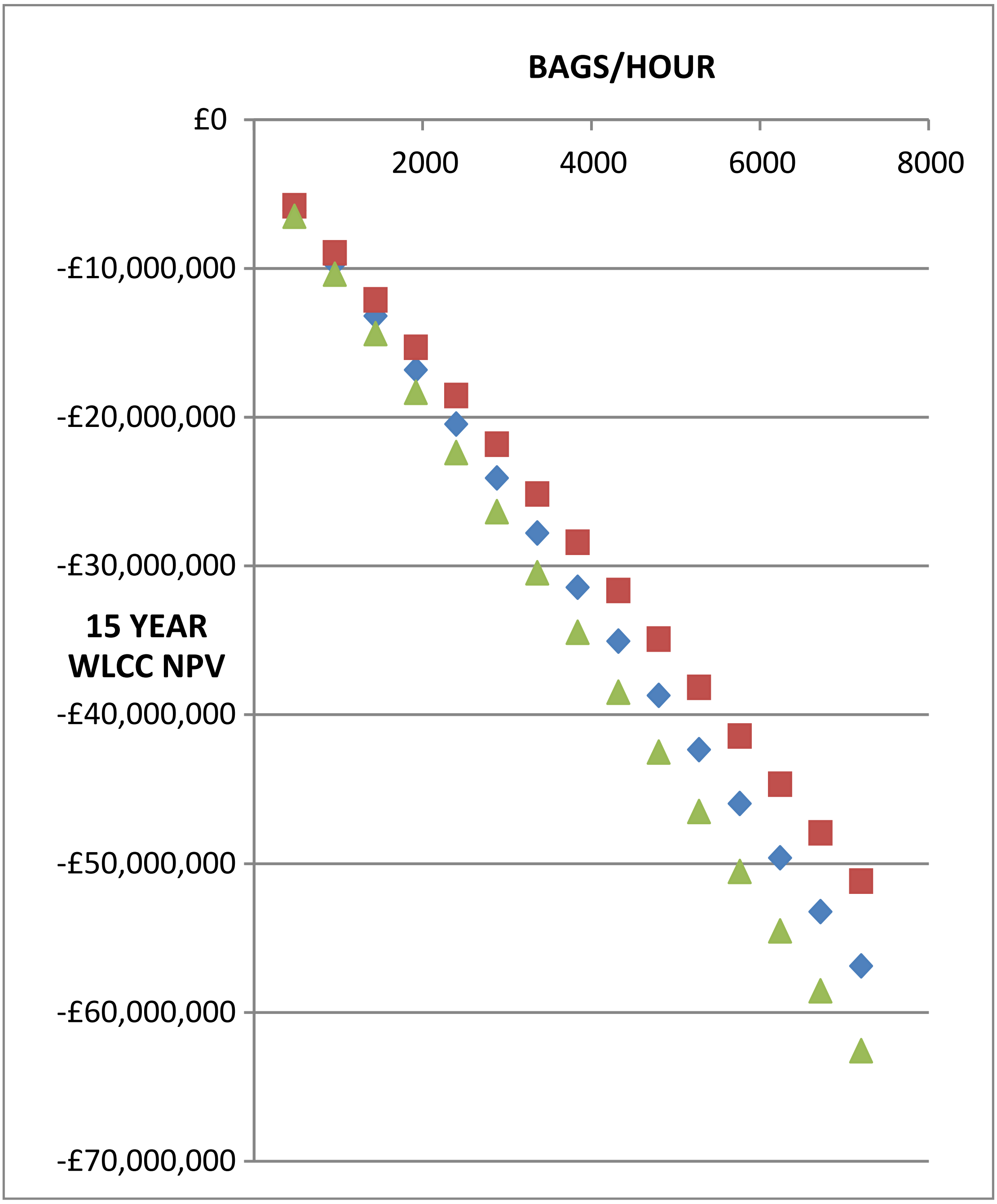


[80] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
1% inflation applied
2bags/min loading rate

Figure 48: Low inflation rate scenario: Long haul only[81]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS

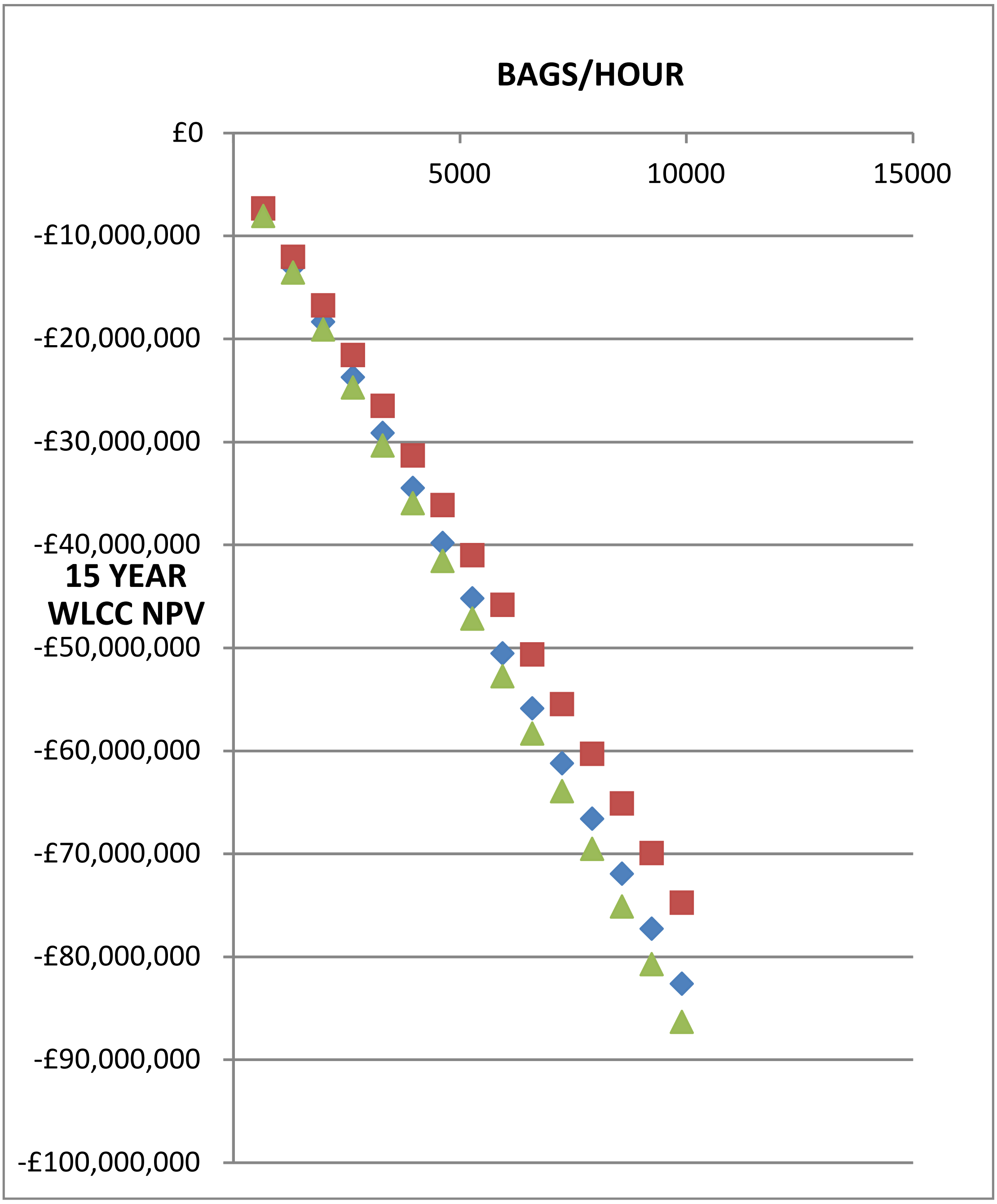


[81] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
1% inflation applied
2bags/min loading rate

Figure 49: Low inflation rate scenario: Short haul / Long haul mix[82]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



[82] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
1% inflation applied
2bags/min loading rate

6.13 Sensitivity high staff loading rate bags/min results

This section contains the results of the WLCC NPV experiments where the high staff loading factor has been applied.

6.13.1 Re: Short haul only

Figure 50 shows that when the high staff loading rate is applied to the model processing short haul traffic only, the resultant BHSs that are produced witness WLCC NPV financial rankings that are different to the base reference point conditions seen in Figure 32. The difference being that in the base case the semi-automatic BHSs are ranked first and the manual BHSs are ranked second. When the high staff loading rate is applied to the short haul traffic scenario this has a positive effect upon the ranking of the manual BHS whereby its WLCC NPV ranking gets promoted to first place. Whilst the change in loading rate is a small numerical variance, from 2bags/minute/operator to 3bags/minute/operator (a 50% increase) the reduction in WLCC NPV that results is very considerable.

It can be seen that the fully automatic BHS solution is the most expensive, the semi-automatic BHS solution is the second cheapest, and the manual BHS solution is the least expensive from a WLCC NPV perspective. The high loading rate has the effect of reducing staff costs which in turn promotes manual BHS WLCC NPV ranking.

6.13.2 Re: Long haul only

With respect to Figure 51 it shows that when the high staff loading rate factor is applied to BHSs processing long haul traffic only, this has no impact on the commercial WLCC NPV rankings of the fully automatic, semi-automatic and manual BHS solutions when compared to the base reference conditions seen in Figure 33.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

6.13.3 Re: Long haul short haul mix

Figure 52 shows that when the high staff loading rate is applied to BHSs processing a combination of short haul, and long haul traffic this has no impact on the commercial WLCC NPV rankings of the BHS solutions when compared to the base reference conditions.

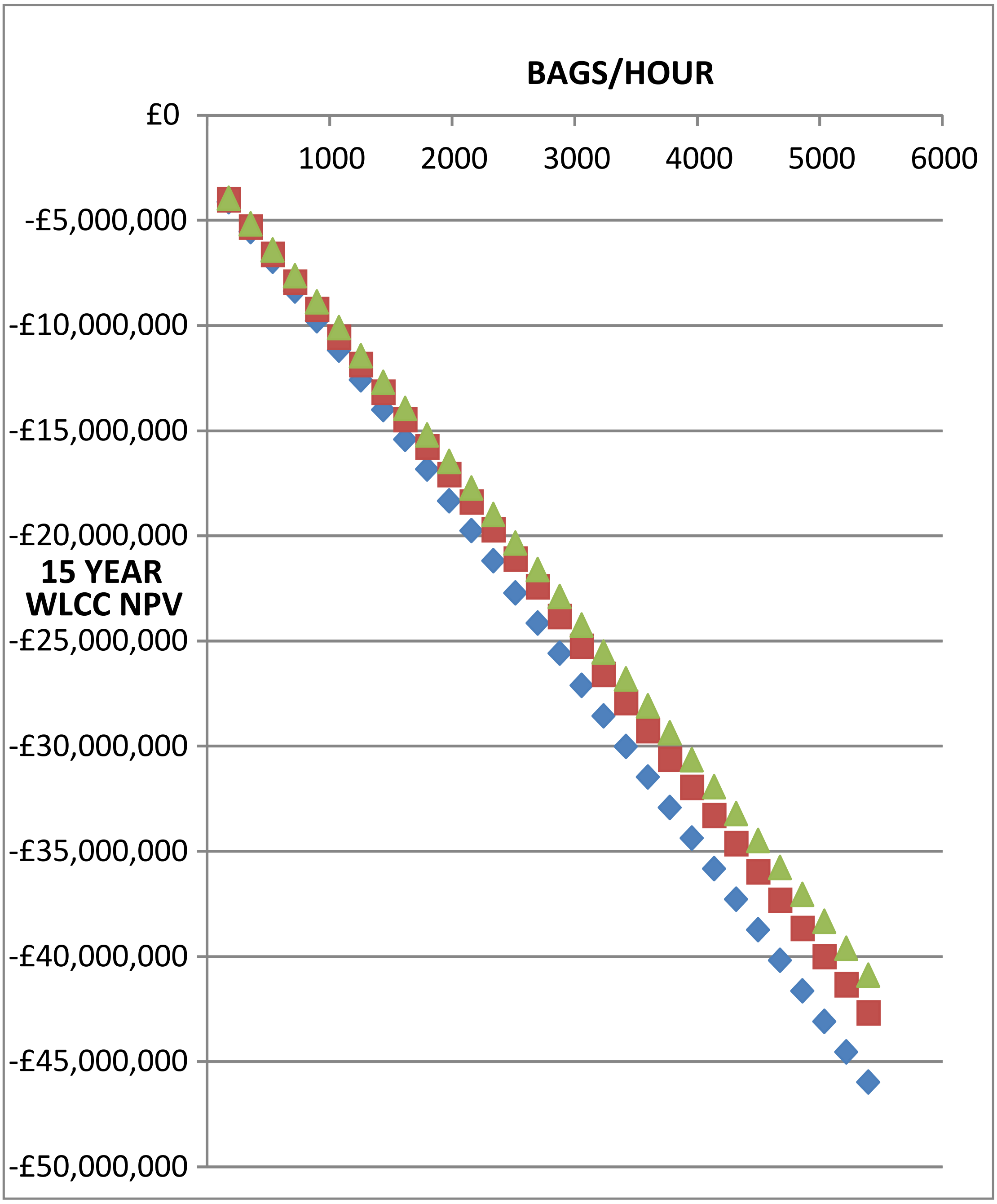
It can be seen that the fully automatic BHS solutions are the second cheapest, the semi- automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

When the high staff loading rate factor is applied, the graphed results of Figure 50, Figure 51, and Figure 52 shows that when processing either (i) long haul or (ii) short haul / long haul mixed traffic, the semi-automated BHSs is the cheapest solution from a WLCC NPV perspective.

Figure 50: High staff loading rate scenario: Short haul only[83]

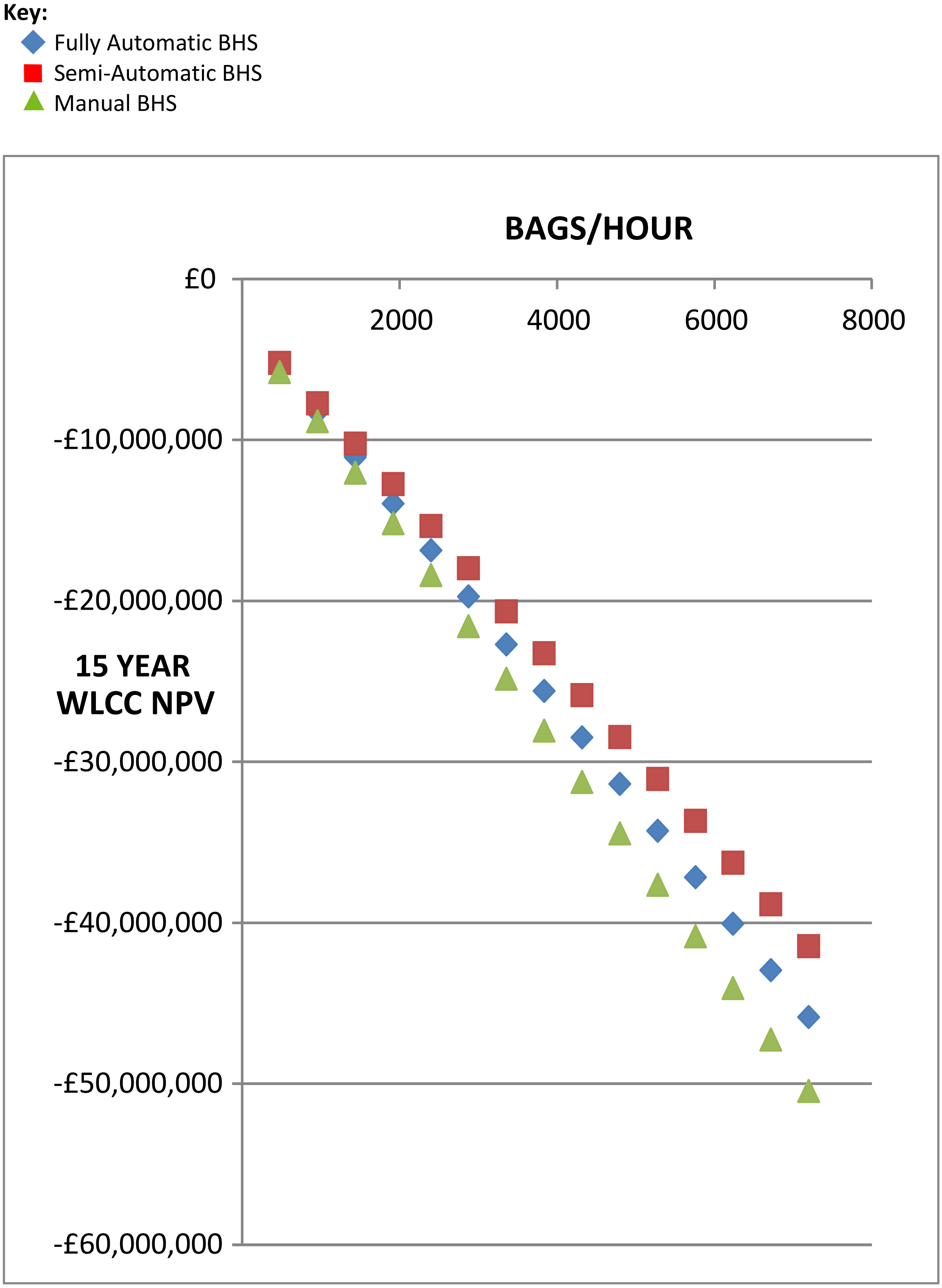
Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



[83] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
3bags/min loading rate

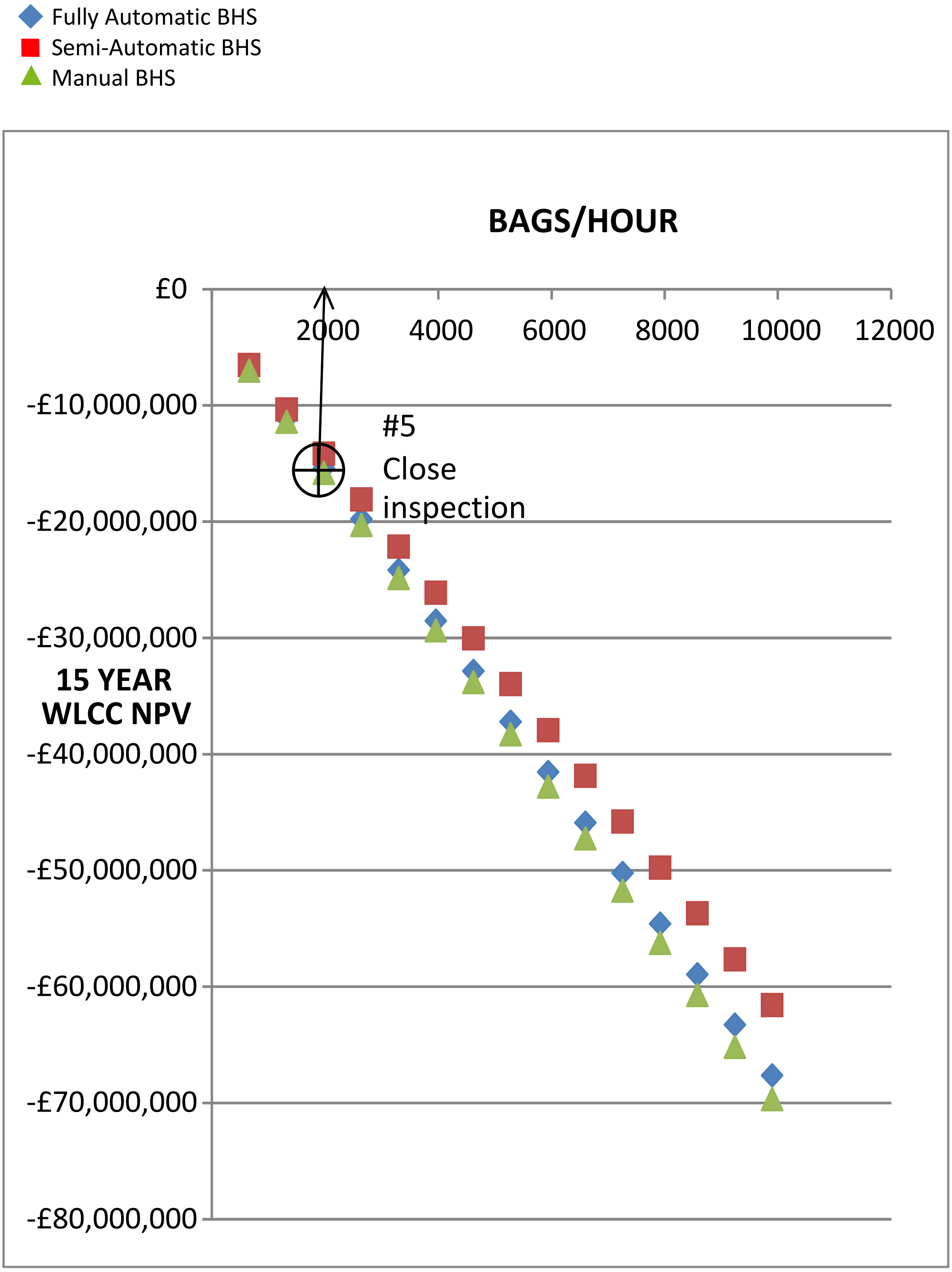
Figure 51: High staff loading rate scenario: Long haul only[84]



[84] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
3bags/min loading rate

Figure 52: High staff loading rate scenario: Short haul / Long haul mix [85]

Key:



[85] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
3bags/min loading rate

6.14 Sensitivity low loading rate bags/min results

This section contains the results of the WLCC NPV experiments where the low staff loading rate factor has been applied.

6.14.1 Re: Short haul only

Figure 53 shows that when the low loading rate sensitivity is applied to the model processing only short haul traffic the WLCC NPV ranking of the BHSs types remain predominantly unchanged when compared to the base reference data seen in Figure 32. There is a small bandwidth though of throughout demand in this scenario where the fully automatic BHS solution type gets promoted to second cheapest and the manual BHSs get demoted to the most expensive solution type (see Appendix H).

It can be seen that the fully automatic BHS solution is predominantly the most expensive, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is predominantly the second cheapest from a WLCC NPV perspective.

6.14.2 Re: Long haul only

Figure 54 shows that when the low loading rate sensitivity is applied to BHSs that process only long haul traffic the WLCC NPV rankings of fully automatic, semi-automatic and manual BHSs remain unchanged when compared to the base reference data seen in Figure 33.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

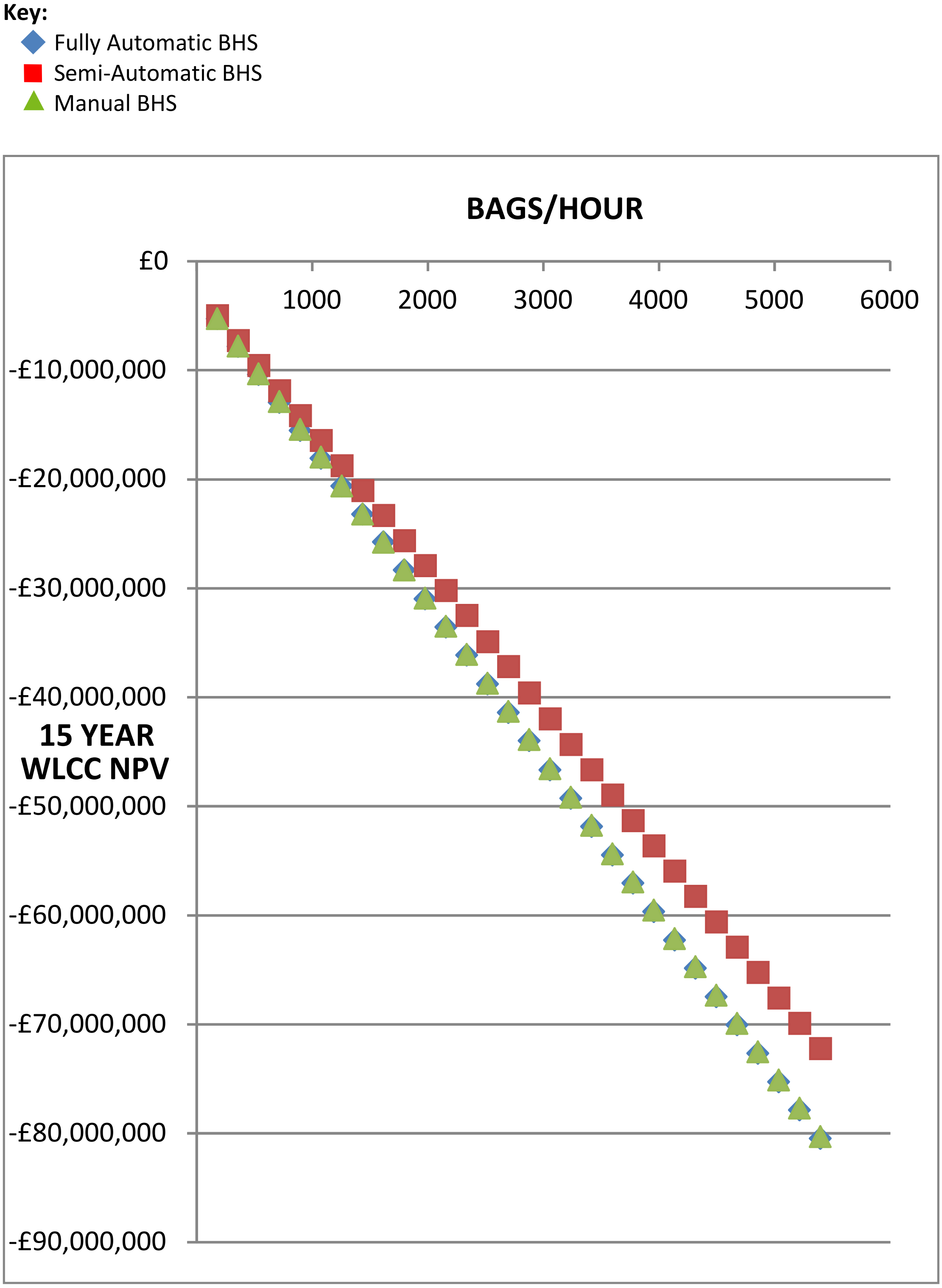
6.14.3 Re: Long haul short haul mix

It can be seen in Figure 55 that when the low loading rate sensitivity is applied to BHSs that process short haul, long haul, and combined long haul short haul mix traffic, the WLCC NPV rankings of fully automatic, semi-automatic and manual BHSs remain unchanged when compared to the base reference data seen in Figure 34.

It can be seen that the fully automatic BHS solution is the second cheapest, the semi-automatic BHS solution is the cheapest, and the manual BHS solution is the most expensive from a WLCC NPV perspective.

When the low staff loading rate factor is applied, the graphed results of Figure 53, Figure 54, and Figure 55 shows that when processing either (i) short haul only; (ii) long haul only; and (iii) combined short haul / long haul mixed traffic, the semi-automated BHSs are the cheapest solution from a WLCC NPV perspective.

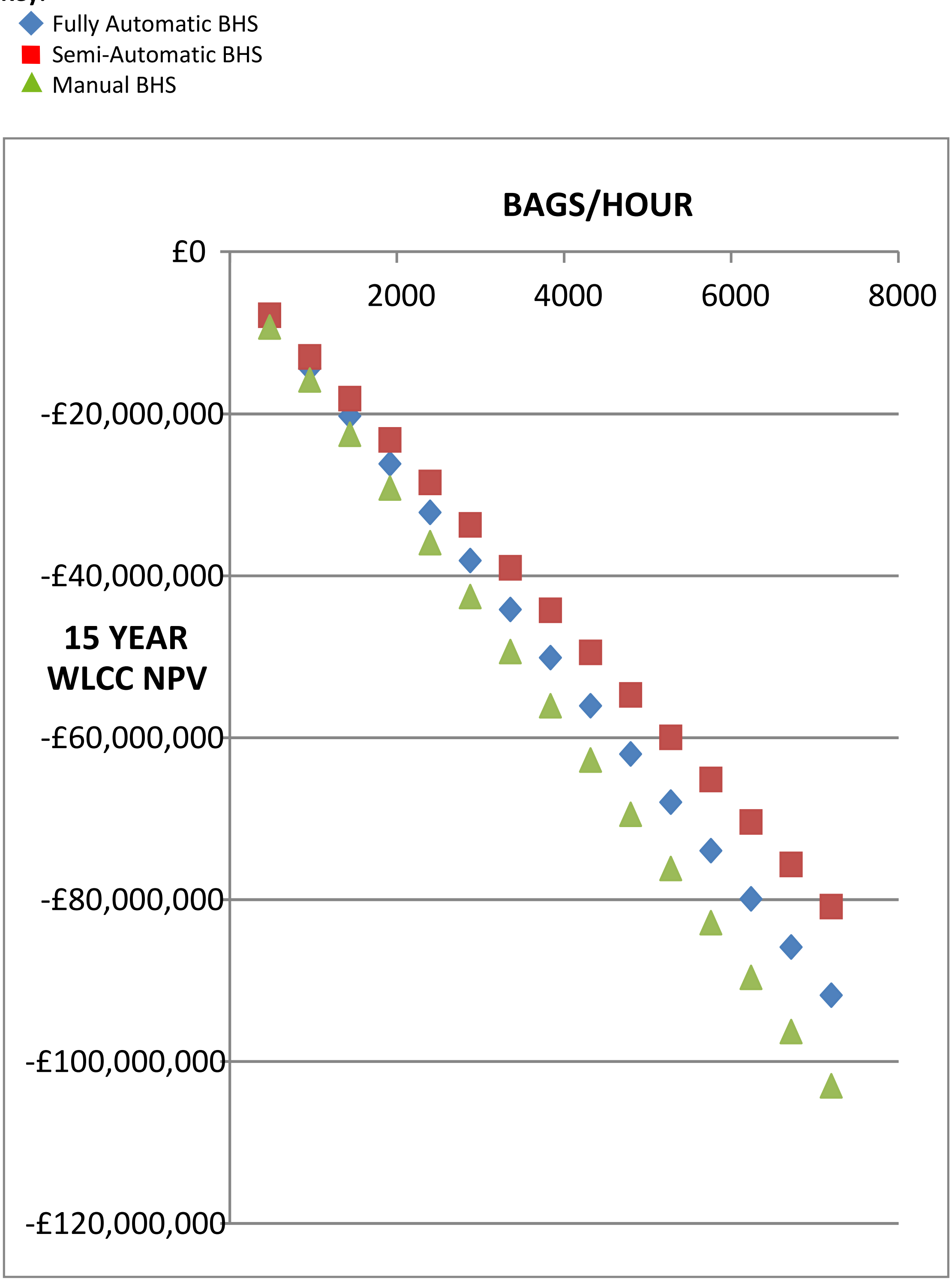
Figure 53: Low staff loading rate scenario: Short haul only[86]



[86] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
1bags/min loading rate

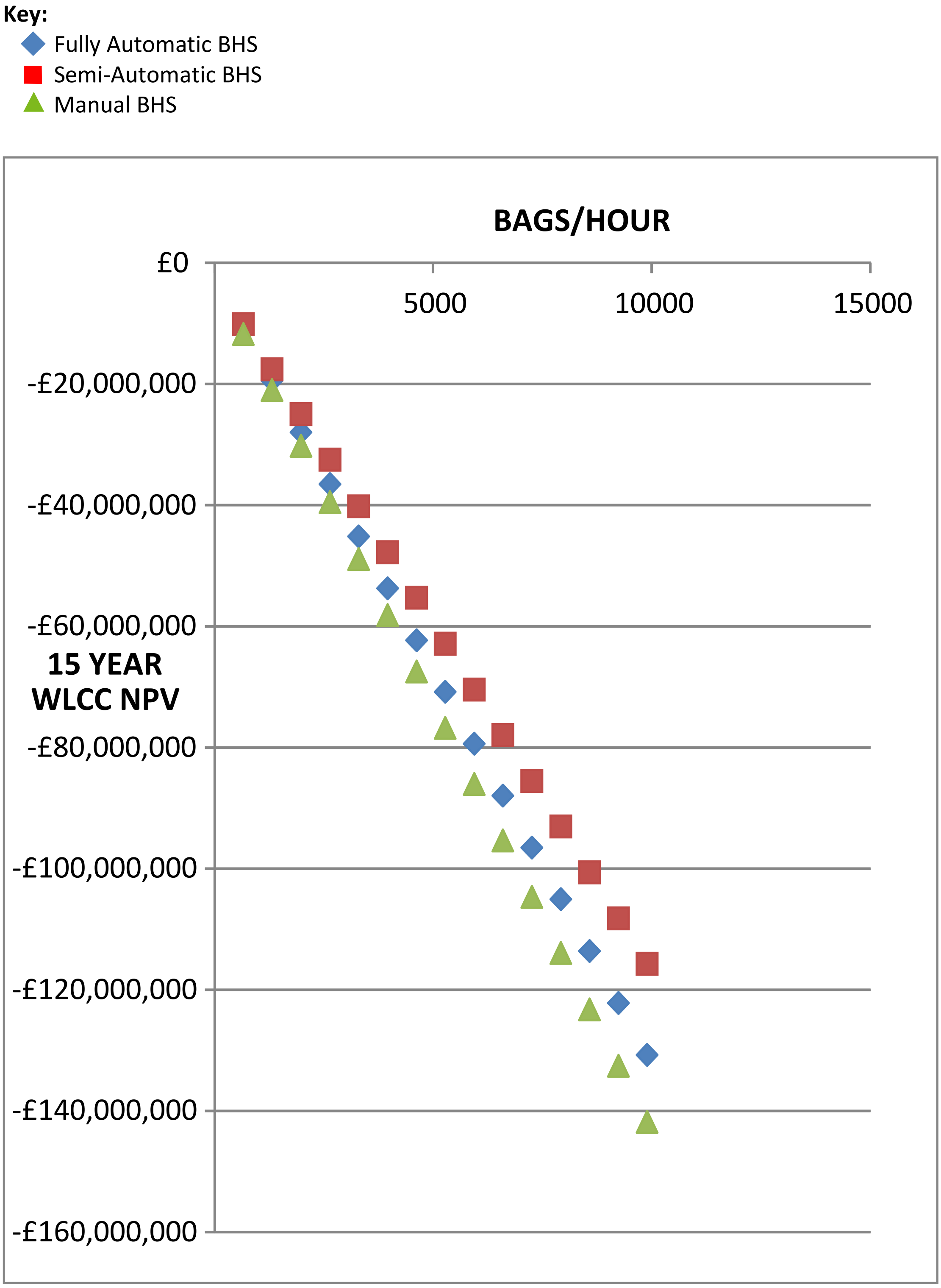
Figure 54: Low staff loading rate scenario: Long haul only[87]

Key:



[87] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
1bags/min loading rate

Figure 55: Low staff loading rate scenario: Short haul /Long haul mix[88]



[88] This figure shows the WLCC NPV results using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
1bags/min loading rate

6.15: Close inspections

The results contained within Figure 29 through to Figure 55 show that under certain WLCC NPV sensitivity scenarios the ranking of the fully automatic, the semi-automatic, and the manual BHSs were witnessed to be commercially very similar. It is at the similar 15 year WLCC NPV values, which relate to specific BHS capacity rates (#1- 1080bags/hr, #2 - 1980 bags/hr, #3 - 3960 bags/hr, #4 -1980 bags/hr, #5 - 1980 bags/hr), where the close inspection examinations have been chosen. The results contained within Figure 29 through to Figure 55 are the total WLCC NPVs which are witnessed at the end of the 15 year period.

Those instances where WLCC NPV ranking are very similar were inspected closely at specific bags/hour rates. This section examines the five inspections points that were graphed with year on year WLCC NPV from year 1 through to year 25.

6.15.1 Re: Inspection #1 BASE reference mid range scenario: Short haul only

It can be seen in Figure 56 that for a BHS processing 1080 bags/hr, at the 15 year WLCC NPV point, the semi-automatic BHS is ranked the cheapest, the manual BHS is ranked second cheapest, and the fully automatic BHS is ranked the most expensive. It is interesting to note from the graphed data shown that the semi-automatic BHS only becomes cheapest from year 13 onward; prior to this the manual BHS solution has the cheapest WLCC NPV. With all BHS options shown the WLCC NPV does not recover to a WLCC NPV of £0 (breakeven point) within 15 years.

6.15.2 Re: Inspection #2 High CAPEX factor scenario: Short haul only

With respect to Figure 57 where BHSs are processing 1980 bags/hr, it can be observed that up-to and including the 25 year point, the manual BHS solution is the cheapest, the semi-automatic BHS type is the second cheapest and the fully automatic BHS type is the most expensive. It can be seen that beyond 25 years the semi-automatic BHS solution is likely to have the least WLCC NPV; this observation assumes that the variables considered remain constant, and that the BHS equipment is fully serviceable and operating within normal original specification limits.

With all BHS options shown the WLCC NPV does not recover to a WLCC NPV of £0 (breakeven point) within 15 years.

6.15. 3 Re: Inspection #3 High CAPEX factor scenario: Long / Short haul mix

Figure 58 details a BHSs processing 3960 bags/hr. At the 15 year life point and thereafter the rankings are maintained with the semi-automatic BHS ranked the cheapest, the fully automatic BHS is ranked the second cheapest and the manual BHS are ranked the most expensive from a WLCC NPV perspective. For the first 3 years of operation the manual BHS is cheaper than the fully automatic BHS, thereafter the fully automatic BHS type becomes cheaper than the manual BHS solution type.

With all BHS options shown the WLCC NPV does not recover to a WLCC NPV of £0 (breakeven point) within 15 years.

6.15.4 Re: Inspection #4 Low OPEX factor scenario: short haul only

It can be seen in Figure 59 that when BHSs are processing 1080 bags/hr at the 15 year life point that the semi-automatic BHS is the second cheapest, the manual BHS is the cheapest, and the fully automatic BHS solution is the most expensive from a WLCC-

NPV perspective. These rankings are maintained through to the 25 year point. With all BHS options shown the WLCC NPV does not recover to a WLCC NPV of £0 (breakeven point) within 15 years.

6.15.5 Re: Inspection #5 High staff loading rate scenario: Short haul / Long haul mix

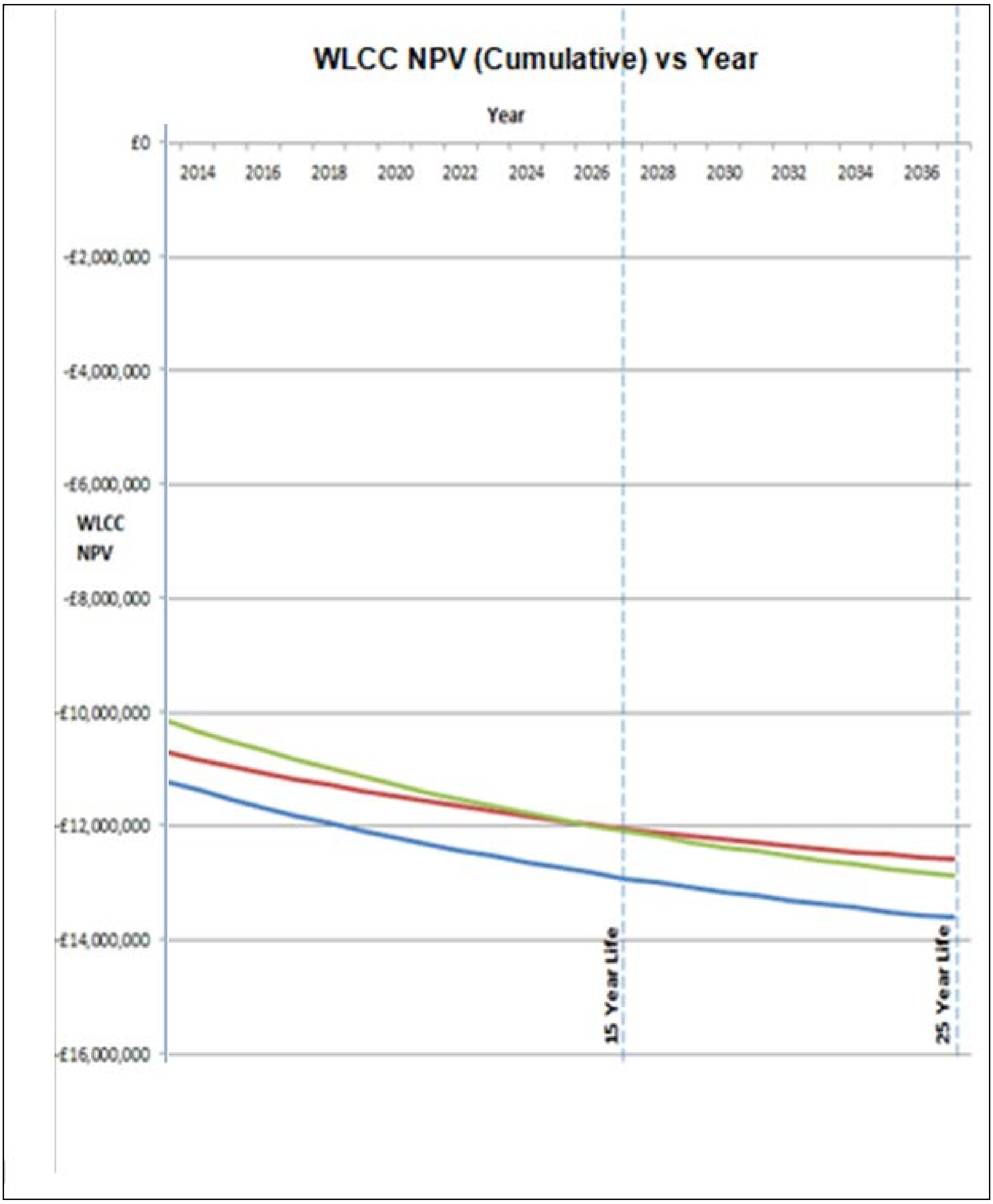
With regard to Figure 60 showing WLCC NPV data for BHSs processing 1980 bags/hr, with a high staff loading rate factor, it is observed that at the 15 year point the semi-automated BHS solution is ranked the cheapest, and remains cheapest thereafter. In year 1 and 2 the manual BHS is the second cheapest, thereafter it becomes the most expensive. In year 1 and 2 the fully automatic BHS type is the most expensive, thereafter it then it becomes the second cheapest.

With all BHS options shown the WLCC NPV does not recover to a WLCC NPV of £0 (breakeven point) within 15 years, however the WLCC NPV amounts in each case do decrease year on year. It is likely that after year 25-30 the WLCC NPV amounts will start to plateau and remain as constants; this observation assumes that the variables considered remain constant, and that the BHS equipment is fully serviceable and operating within normal original specification limits.

Figure 56: Close inspection #1 at 1080 bags/hr[89]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS

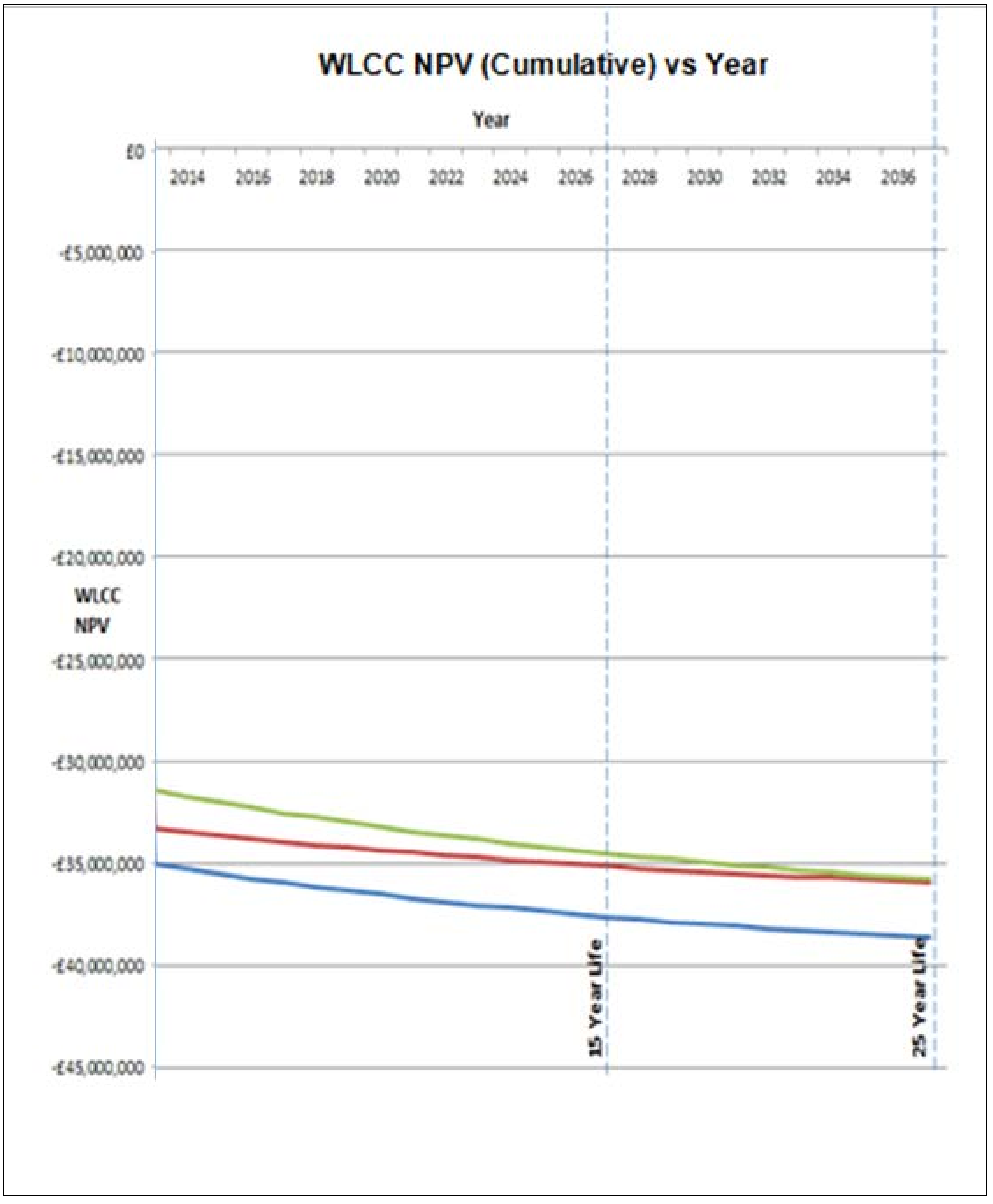


89 BASE reference mid-range scenario: Short Haul Only
This figure shows the WLCC NPV results at 1080 bags/hr using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 57: Close inspection #2 at 1980 bags/hr[90]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



[90] High CAPEX factor scenario: Short Haul Only
This figure shows the WLCC NPV results at 1980 bags/hr using the following input parameters.
110% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

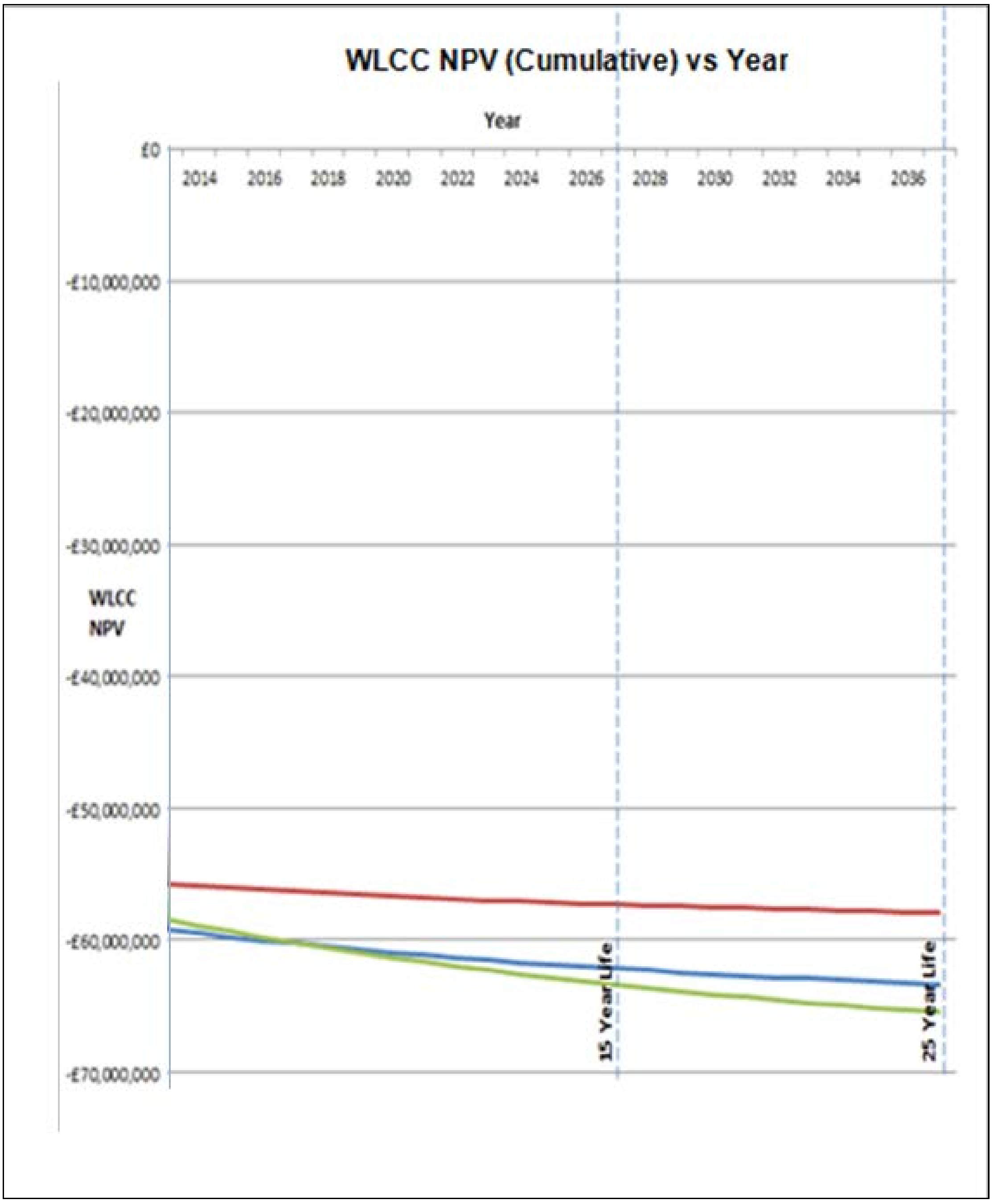
Figure 58: Close inspection #3 at 3960 bags/hr[91]

Key:

Fully Automatic BHS

Semi-Automatic BHS

Manual BHS

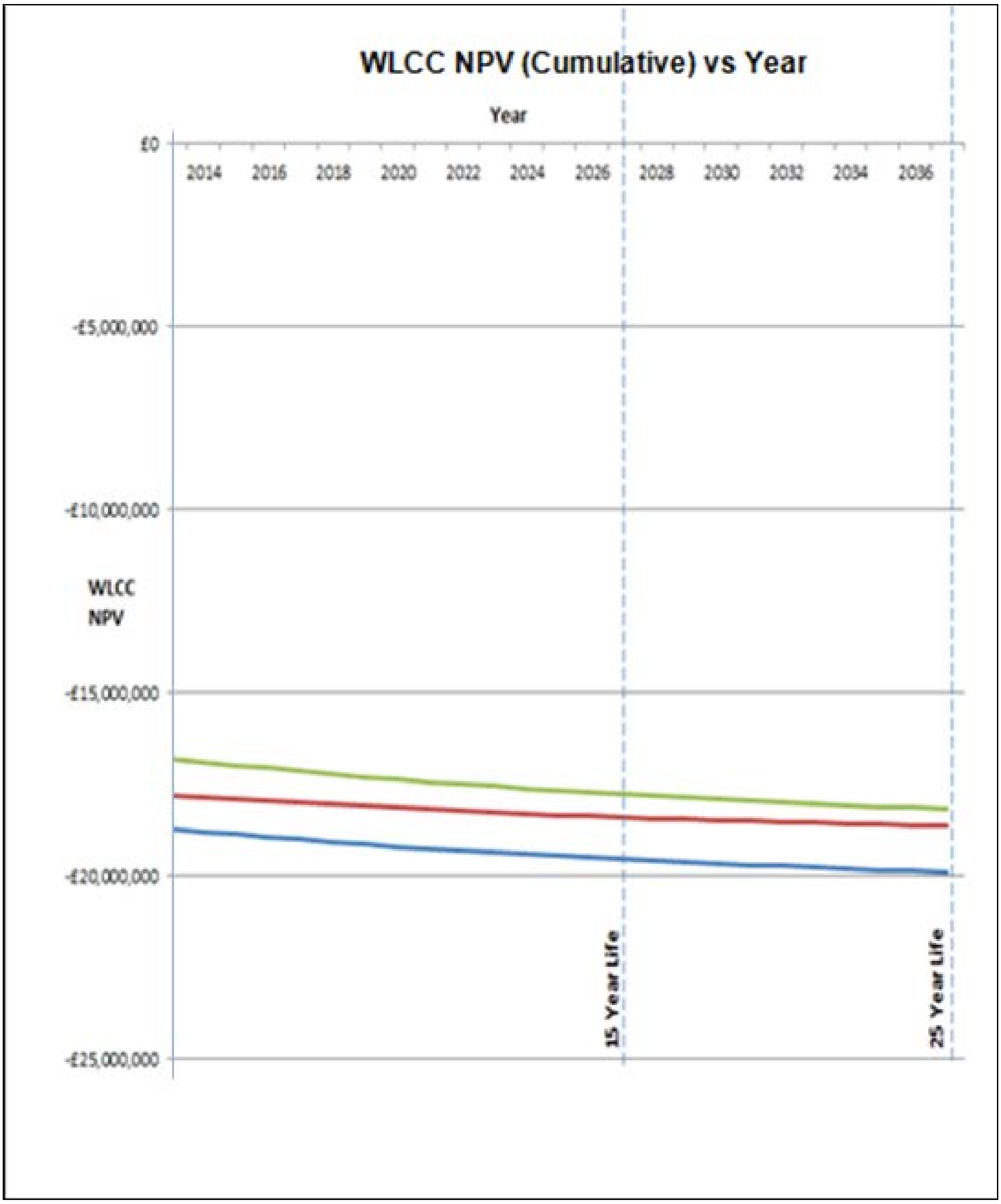


[91] High CAPEX factor scenario: Long / Short Haul Mix
This figure shows the WLCC NPV results at 3960 bags/hr using the following input parameters.
110% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 59: Close inspection #4 at 1980 bags/hr[92]

Key:

Fully Automatic BHS
Semi-Automatic BHS
Manual BHS

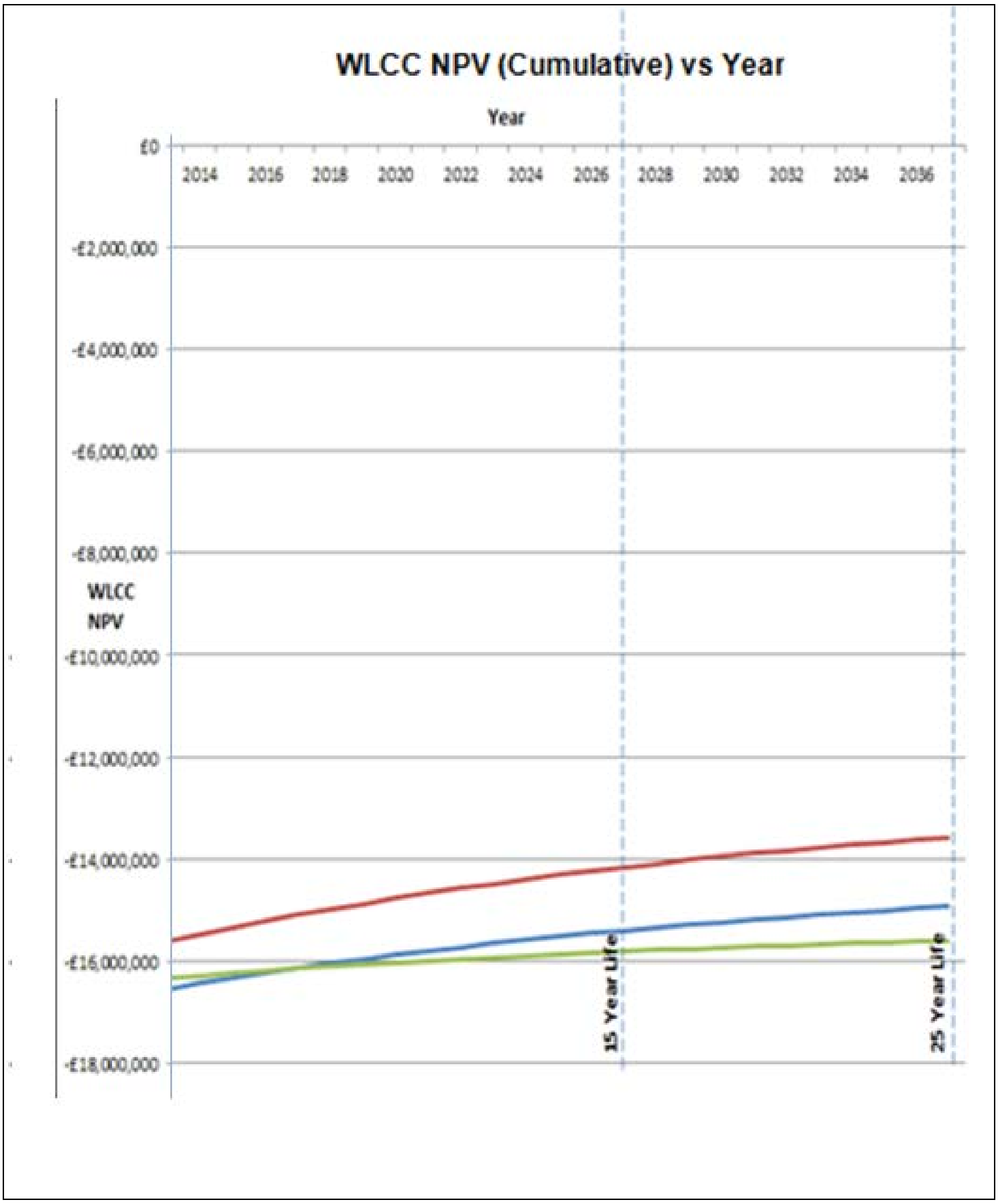


[92] Low OPEX factor scenario: Short Haul Only
This figure shows the WLCC NPV results at 1980 bags/hr using the following input parameters.
59% CAPEX factor applied
19% OPEX factor applied
3% inflation applied
2bags/min loading rate

Figure 60: Close inspection #5 at 1980 bags/hr[93]

Key:

- Fully Automatic BHS
- Semi-Automatic BHS
- Manual BHS



93 High staff loading rate (Bags/Min) scenario: Long and Short Haul Mix
This figure shows the WLCC NPV results at 1980 bags/hr using the following input parameters.
59% CAPEX factor applied
59% OPEX factor applied
3% inflation applied
3bags/min loading rate

It can be seen from the close inspections shown within Figure 56 to Figure 60 inclusive that the financial viability of BHSs can change throughout the normal 15 year life period for a BHS and indeed after this period.

BHSs that have high staff loading rates will recover their costs significantly quicker than those that do not.

6.16 Pre results validation

Once the model was completed, and prior to the tests being carried out, it was necessary to validate/benchmark the output, Merkert R, Odeck J, Brathen S, Pagliari R, (2012), to ascertain if the model generated credible results. Obtaining real relevant airport baggage system reference data has proved to be quite challenging, as it was necessary to approach independent baggage system designers to obtain the required data. The principle of the validation exercise was to compare actual data for the reference airports obtained with data output generated from the model using the same flight schedule inputs (see appendix B and Figure 61 – "Flight Schedule Peak Flights/Hour" column). The model BHS capital cost output were then calibrated so that discrepancies in bags/hour processed, resultant baggage hall areas, and the conversion from £'s sterling into Euros was taken into account.

The model generates many technical and financial outputs as detailed in Figure 7 when flight schedule inputs are entered into the Input variables worksheet. The model requires the following inputs before it will generate output result data:

- # of Short Haul Flights / Hour : Main flight schedule input, the model uses a typical Code C aircraft, 180 seats and 1 bag / passenger ratio applied.

- # of Long Haul Flights / Hour: Main flight schedule input, the model uses a typical Code E aircraft, 400 seats and 1.2 bags / passenger ratio applied.
- Peaking Factor %: Set at zero[94] for the benchmarking activity.
- CAPEX Factor: Set at one[95] (UK 2011 prices) for the benchmarking activity.
- OPEX Factor[96]: Not required for the benchmarking activity.
- Inflation Rate[97]: Not required for the benchmarking activity.
- Staff loading Rate Bags/Min: Set at the base loading rate of
- 2 bags/min/operator.

This input information was provided by the designer of Schiphol Airport, Terminal 1 ('South'), Bergen Airport New Terminal, Oslo Airport Terminal 2 and Johannesburg airport.

Figure 61: Validation: Actual airport data vs Calibrated model data

AIRPORT	ACTUAL AIRPORT DATA						CALIBRATION Factor function F(x) Bags/hr+ Area Exchange rate £1 = 0.86 euro	CALIBRATED EMPIRICAL MODEL OUTPUT	
	Flight Schedule Peak Flights/hour		Rate	BHS CAPEX	BHS Area	BHS Process		CAPEX	BHS Area
	#SH	#LH	Bph	Euros	m2			Euros	m2
Schiphol T1 ('South')	27	0	2393	122,000,000	19,914	Pull (automation)	0.99	36,441,544	11,402
Bergen New Terminal	10	4	3720	20,000,000	8,750	Pull (automation)	1.25	29,708,706	10,174
Oslo T2 (Scenario 4)	39	1	3700	40,000,000	13,100	Push (conventional)	0.74	30,239,137	12,398
Johannesburg	4	12	6480	50,000,000	17,000	Push (conventional)	1.40	49,173,592	19,767

BHS designers, were approached and asked to provide actual airport BHS data. The actual airport data seen in

[94] Validation peaking factor: As with the main experiments excessive peak flow have not been assumed when calculating the validation data.
[95] Validation CAPEX Factor: All data was converted to UK prices (Factor = 1) then converted into Euros.
[96] Validation OPEX Factor: OPEX is not used in the CAPEX calculation hence is not required
[97] Validation inflation rate: Inflation is not used in the CAPEX year 1 calculation hence is not required.

Figure 61 represents the output from those investigations. A benchmarking comparison was made between the obtained actual airport data, and the data calculated by the model. In particular the BHS capital cost, and the BHS total area, were compared. Following the calibration[98] exercise, it can be seen from

Figure 61 that, overall the model generated credible results, taking into account the multiple variables that are evidently affecting the BHS capital cost and the BHS total area.

Red cells indicate that the actual airport data does not compare favorably with the model data (variance is greater than 75%), Amber cells indicates that a reasonable comparison exists (variance is less than 33%), and Green cells indicate that a very good comparison exists (variance is less than 14%).

When running the model to create the data contained in Figure 61 above, for each scenario that was examined, the correct allocation of full automatic (robotic), and semi–automatic (RTT), and manual flight build technologies was made.

The Schiphol Terminal 1 South building is an old (~1960's) terminal building area. This airport offers a complicated and convoluted building area which has undoubtedly added a cost to the conveyors, and the resultant area needed is excessive due to abnormally long conveyor routings that are needed. The capital cost for Schiphol baggage system was reported by the independent cost consultant to be 122,000,000 Euros for the baggage system components alone. This is significantly more expensive than comparable modern baggage systems of the same capacity. For this reason this

[98] Calibration: Process by which the WLCC model derived data has been adjusted by the calibration factor. This factor, takes into account the affect of the exchange rate, the variation in bags processed per hour rate, and the variation in area.

has been excluded as potentially abnormal data that should really be discounted from the comparison exercise.

The actual area of the Bergen new terminal building solution is a close match to that generated using the model, whereas there the baggage system cost is slightly inaccurate. This is likely to be due to the variation in IATA 2003 cost factors, used within the model, compared to that of the witnessed 2011 cost factors for this region of the world. The model predicted a 75% accurate cost of the Oslo airport Terminal 2 baggage system. This again may be due to a variation between the IATA 2003 CAPEX factors compared with the actual witnessed 2011 national cost factors. The area predication made by the model for Bergen is very accurate.

The actual costs of Johannesburg baggage handling system and the area of the baggage handling system compared favorably to that generated by the model.

Since the model generated a favorable and reasonable comparison between actual airport data, and the theoretical calculated data output, it was not necessary to instigate any major adjustments to the model before the experimentation stage was completed.

The model was then used to generate the results contained herein.

6.17 Chapter summary

The Chapter explained how the results to the experiments were consistently captured by using a sub routine program to record the results data, which is denoted in Appendix H.

This Chapter graphically documents the results from each of the sensitivity tests that were conducted using the model. The WLCC NPV commercial rankings for each BHS flight build type are explained for each test. Where initial WLCC NPV tests results showed positions of data that warranted further close inspection because the results were commercially similar in magnitude, then a further inspection on such positions was carried out. Furthermore these close inspection plots were examined on 15, and 25 year WLCC NPV periods.

It was seen that in some instances, even with a modest £1/bag processed bag charge, it is possible to start to recover the WLCC NPV for a BHS development. It was noted that the cost / bag heavily influences the WLCC NPV.

Finally this section also explains how prior to running the experiments and obtaining the test results contained herein from the model a benchmarking process was carried out to ensure that the output from the model gave realistic results, which was proven to be the case. Chapter 6 that follows takes the data from individual tests, and assesses that data collectively, and concludes facts.

7. DISCUSSION

7.1 Main findings

This Chapter discusses the conclusions and main findings of the results obtained from the experiments carried out using the model. Answers to the research aims and objectives are provided using evidence from the research and the tests. The main findings are graphically summarized in Figure 63 that follows together with an explanation on how the utilize the findings appropriately.

The scatter diagram shown in Figure 63 denotes the summarized graphed results of all experiment scenarios, which are seen within Figure 29 through to Figure 55 inclusive. The WLCC NPV range for the IATA category A BHS solution is noted to be -£1m to -£20m. The WLCC NPV range for the IATA category B BHS solution is noted to be -£5m to -£90m. The WLCC NPV range for the IATA category C BHS solutions, are noted to be -£12m to greater than -£150m. These ranges relate to specific bags/hour capacities, and BHS technology solutions.

The wide WLCC NPV range within each category is a result of many factors that affect the WLCC NPV, not least (i) change in bags/hour rate; (ii) change in BHS solution type, (iii) sensitivity test parameter, e.g. High CAPEX / LOW CAPEX etc.

With respect to Figure 63 there are three poly trend[99] lines (see clauses 7.4, 7.5 and 7.6) that have been shown, these poly trend plots have been calculated for each BHS solution type (fully automatic, semi-automatic, and manual) using WLCC NPV data

[99] Poly trend lines: Each poly trend line is a summation of the 15 year WLCC sensitivity data per BHS capacity rate. A poly trend line is calculated for each type of BHS (Blue -Fully automatic, Red - Semi-automatic and Green - Manual)

from Appendix H. The WLCC NPV data for each BHS type has been averaged out, and the resultant mean value ploy trend coordinates have been plotted.

These averaged poly trend line plots take into account all the test sensitivities that have been evaluated, and they are the graphical answer to the aim of PhD.

7.1.1 Linearity of scatter diagram results

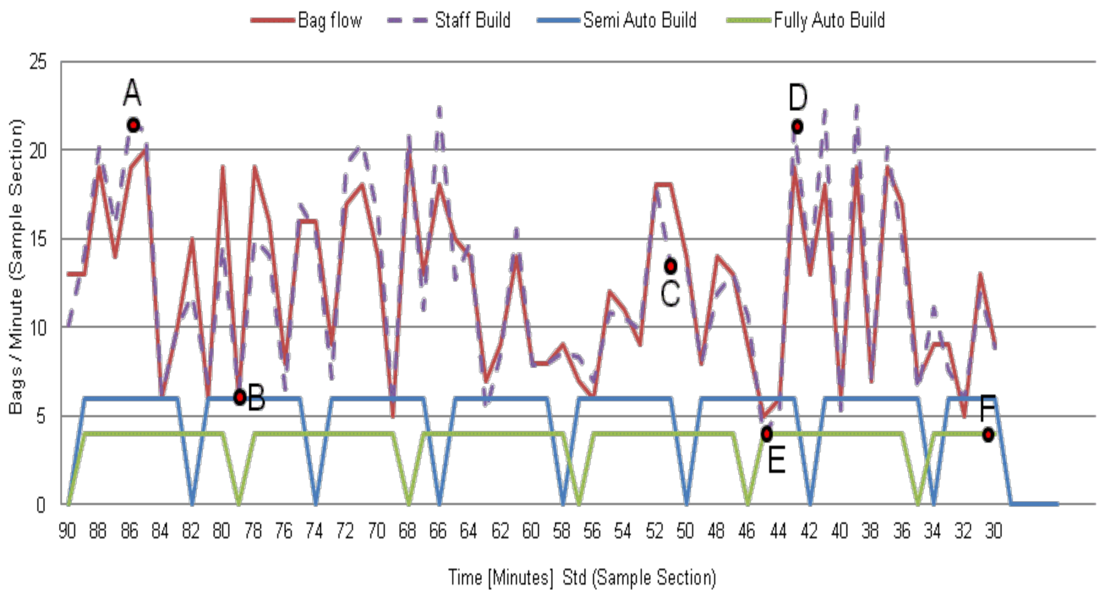
Figure 63 references the year 15 spot WLCC NPV data for each BHS type and capacity tested. The graphed data seen in Figure 63 is correctly shown to be very linear. Fundamentally this is because the results are the cumulative spot year values seen in year 15 only for each test. Figure 63 does not show the year on year WLCC NPV values. The year on year non-linear cumulative WLCC NPV data is however inherently taken into account within the year 15 spot WLCC NPV data used in Figure 63. The year on year non-linear data detail can be seen within the sample close inspections graphs denoted within Figure 56, Figure 57, Figure 58, Figure 59, and Figure 60.

7.2 Answering the objectives

Figure 62 articulates how PhD objective 1, that is, to determine the point at which it is operationally most effective to use semi-automatic, and fully automatic baggage loading technologies was answered. It is possible to construct a BHS which will contain 100% fully automatic (robotic) build, or 100% semi-automatic build technology. It is equally possible to reduce these percentages so that effectively only one fully, or one semi-automatic build cell is present. These technologies have different bags/minute processing capabilities. This section determines the point at which it is operationally most effective to use semi-automatic, and fully automatic baggage loading technologies, and answers objective 1.

The flow denoted in Figure 62 below shows that for the stated sample, the baseline “bag flow” demand is 5 bags/minute.

Figure 62: Demand and capacity



The sustained processing rate of a semi-automatic build device such as the RTT Longreach (Telair International) unit is noted to be 6 bags / minute / unit.

The sustained processing rate of fully automatic robotic build device such as the Grenzenbach solution is witnessed to be 4 bags / minute / unit.

Figure 62 shows, the productive, and non-productive graphed cycle time of a both semi-automatic, and a fully automatic build cells. Unlike the flexible deployment of human resources, it is inefficient to under-utilize a fixed hardware resource such as the semi-automated or fully automated build cell equipment.

With respect to Figure 62 Points A, and D show an over compensation in predicted required staff capacity compared with the actual proceeding flow rate of baggage within the system. Point B shows the baseline demand witnessed for the sample bag flow.

From Figure 62 one can conclude that a single fully automatic build cell would be close to 100% utilised if processing the stated sampled bag flow as its capacity (note Point F) is 4bags/minute/unit which is below the baseline demand of 5 bags/minute (note Point E). If two fully automatic build cells were deployed one would be heavily under utilised.

Similarly for the baggage flow demand depicted, if a single semi-automatic build cell were deployed with its 6 bags/minute/unit throughput rate it would be under-utilised by 1 bags/min/rate. If two semi-automatic build cells were deployed both would be under-utilised, and one would be extremely under-utilised. The BHSs deployed at AMS, and at LHR both incorporate a ~25% output capacity proportion of fully-automated/semi-automated components with ~ 75% of the remaining output being conventional technology (flight laterals or racetracks). These proportions provide confidence that these relatively expensive robotic, and RTT equipment tools will be highly utilised, whilst giving the ability to the airport to react efficiently to oscillatory periods of high peak demand. Fundamentally the proportion of semi-automated, or fully automated flight build equipment used should be driven by the proportion of sustained bag flow rate demand. If it can be demonstrated through analysis of the flight schedule that the sustained baggage flow throughput demand is 25% then 25% semi-automatic or fully automatic equipment should be used. Similarly if say the sustained bag flow rate demand is 40% then 40% of semi-automatic or fully automatic equipment capacity should be selected. With reference to Figure 4 Real time Push/Pull Bag Automated Bag Load Philosophy diagram it can be seen that the at STD-60 minutes the baggage entering the BHS is considered to be “Hot build” bags. Due to the extended “in system time” associated with processing baggage through the hot build process it becomes necessary to build these bags using the conventional build process. This means that there will always be a need to build flights using a proportion of conventional build technology. Table 8 that follows explains the minimum, maximum, and recommended percentage of build type that can be used.

Table 8: Build type proportion summary

	Build type used		
Build Type	Minimum %	EM Recommended %	Maximum %
Conventional	25%[100]	75%	100%
Semi-automated Or Fully automated	Match Sustained[101] Demand	25%[102]	75%

Section 2.4 that is entitled “Baggage Operational Processes” answers PhD Objective 2, that is to determine what new semi, and fully automated and conventional baggage handling processes, and technologies exist, the performance capabilities of these technologies, for the use of loading of baggage into unit load devices.

[100] Typically 25% of bags are yet to be processed at the STD-60 Hot Build point (using equation 27)

[101] Figure 72 shows that the minimum quantity of semi-automated and fully automated build is best set by matching equipment processing rate to sustained demand rate.

[102] Reference AMS/LHR airport semi-automated and fully automated BHS each utilise 25% of this output build equipment.

The available processes were collated during the research of literature phase, and the recommended processes as defined within Figure 67, Figure 68, Figure 70, Figure 71, Figure 73, and Figure 74 are embedded with the model.

Chapter 3, 5, and Appendix H answers the PhD objective 3, that is, to investigate and determine the capital, and operating costs for semi, and fully automated, and conventional (manual) airport BHSs, through the development of the model. The results provided in Appendix H define the required output CAPEX, and OPEX for the various investigated BHS types. These were then used to determine the WLCC NPV comparisons. Objective 4 is also answered through the development of the model defined in Chapter 3 and 5,

7.3 Meeting the aim of the PhD investigation.

To recap the aim of the research was to determine, for any given set of baggage demand flows rates, the point at which it is more cost effective, from a capital cost and operating cost perspective, to select automated baggage build technologies in favour of conventional baggage build technologies when processing departing hold baggage.

With reference to Figure 63, and in particular the poly trend line WLCC NPV plots, taking into consideration capital cost, operating cost, bag charge revenue and all applied test sensitivities, one can conclude that the lowest WLCC NPV values, by far, shall be found with the semi-automatic BHS type. Between zero and 4000bags/hour, the manual BHS type is the second cheapest overall, and the fully automatic BHS type is marginally the most expensive from a WLCC NPV perspective. After this 4000bags/hour point the fully automatic BHS type becomes the second cheapest, and the manual BHS type becomes the most expensive from a WLCC NPV perspective. Furthermore, beyond the 4000bags/hour point the manual BHS WLCC NPV then progressively gets more and more expensive.

7.4 The α - Poly trend plot

It can be seen from the "α" poly trend plot within Figure 63 that the WLCC NPV for the fully automatic BHS solution tends to plateau [103] out and arguably would payback[104] albeit over an extended equipment life period.

7.5 The β - Poly trend plot

It can be seen from the "β" poly trend plot within Figure 63 that the WLCC NPV for the semi-automatic BHS solution also tends to plateau out and arguably would payback albeit over an extended equipment life period also.

7.6 The δ - Poly trend plot

It can be seen from the "δ" poly trend plot within Figure 63 that the WLCC NPV for the manual BHS solution tends to deviate away from the payback position. Payback would not occur for the majority of these manual BHS systems even over an extended equipment life period.

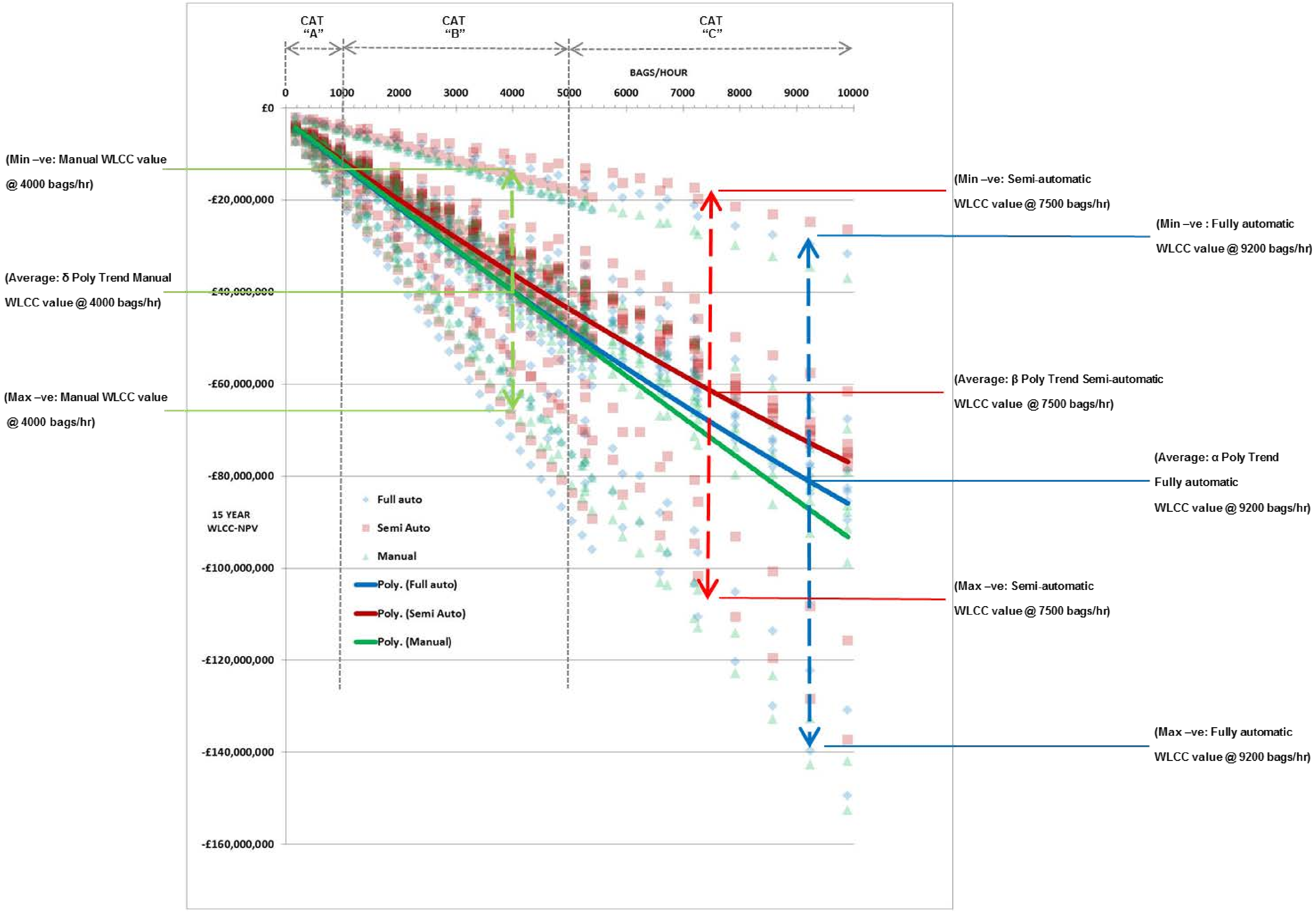
In conclusion it is clear that the WLCC NPV range of BHS solutions is heavily influenced by commercial, and performance sensitivities that have been tested within the experiments. When an airport makes a BHS technology selection judgment for a

[103] Plateau: Point at which the WLCC NPV start to be maintained at a relatively constant rate.
[104] Payback: With reference to graphs of "year in operation vs WLCC NPV", this is the year when the WLCC NPV has the numerical value of zero.

particular airport location, the prevailing commercial and social economic conditions should be taken into account. For example if an airport is located in an area where the capital cost of the solution is going to be adversely high when compared to other locations of the world, then the airport operator should be less steered by the general results seen in Figure 63, and instead should consider the results, and conclusions made with high CAPEX experiment results seen in Figure 29, Figure 30, and Figure 31. Inversely, and similarly if the airport company making the BHS type decision is geographically located in a zone where capital cost are lower than average, then the they should be steered by the results and conclusion documented in Figure 35, Figure 36, and Figure 37.

The results obtained from the model were focused on changing only one test sensitivity at a time, relative to the base results. It is quite possible that an airport operator with the objective of making a bespoke decision may actually need to take into account more than one test sensitivity. A specific mix of the test sensitivities to achieve an accurate representation of the social economic environment that exists at the proposed airport BHS location maybe required. For example geographically the capital cost could be average but the operating cost could be relatively low initially, but it is anticipated that in the not too distance future, that the operating costs could climb, and hence a high inflation factor should be used in the model calculation. It is also quite possible that the staff work loading rate could be higher than average, and so a further sensitivity needs to be taken into account in parallel. The poly line data conclusions seen in Figure 63 provide the most relevant conclusion for the scenario where all of the test sensitivities are taken into account simultaneously.

Figure 63: Summary scatter diagram all scenarios: Long and short haul[105]



105 This figure shows all the WLCC NPV (Discounted) results using all of sensitivities scenarios denoted in the following input parameters.
19% - 59% - 110% CAPEX factor applied
19% - 59% - 110% OPEX factor applied
1% - 3% - 7% inflation applied
1 – 2 – 3 bags/min loading rate

7.7 Sensitivity conclusions

From the results, and conclusions provided in Chapter 5, and the findings tabulated in Table 9, Table 10, and Table 11 it can be seen that the selected sensitivities can have varied impact upon the financial WLCC NPV ranking (position) of the BHSs that were technically constructed, and financially assessed within the model environment.

Table 9: Effect of test sensitivities upon BHS WLCC NPV relative to base conditions for short haul traffic.

		WLCC Ranking	
Sensitivity	First place Lowest[106]	Second place	Third place Highest[107]
Base	Semi-automatic	Manual	Fully automatic
High CAPEX	Manual	Semi-automatic	Fully automatic
Low CAPEX	Semi-automatic	Manual	Fully automatic
High OPEX	Semi-automatic	Manual	Fully automatic
Low OPEX	Manual	Semi-automatic	Fully automatic
High inflation	Semi-automatic	Manual	Fully automatic
Low inflation	Semi-automatic	Manual	Fully automatic
High staff loading rate	Manual	Semi-automatic	Fully-automatic
Low staff loading rate	Semi-automatic	Manual[108]	Fully automatic[109]

The greatest change in WLCC NPV ranking is witnessed when processing short haul traffic as denoted in Table 9.

A CAPEX, OPEX, and area summary report for a BHS processing 2340 bags/hour of short haul traffic is detailed in Figure 64. A CAPEX, OPEX, and area summary report for a BHS processing 2340 bags/hour of long haul traffic is detailed in Figure 65.

It can be seen in Figure 64, and Figure 65 that:

[106] Definition “Lowest” - The WLCC has the lowest numerical value
[107] Definition “Highest” – The WLCC has the highest numerical value
[108] Manual solution is predominantly ranked second place
[109] Fully automatic is predominantly ranked third place

- The short haul BHSs have the greatest BHS CAPEX differential (delta) between BHS types (£917,684 vs £674,377).
- The short haul BHSs have the lowest Building CAPEX differential (delta) between BHS types (£1,133,206 vs £ £1,661,658)
- Has the least building area differential (delta) between BHS types (186m2 vs 641m2)
- The short haul BHSs has the greatest BHS CAPEX (£9,001,527)
- The short haul BHSs has the greatest Building CAPEX (£10,175,703)
- The short haul BHSs has the greatest Building area requirement (3219m2)

The main cause of the heightened sensitivity of the WLCC ranking (first, second or third place) when processing short haul traffic only can, in part, be explained by the fact that for short haul BHS solutions, typically the building CAPEX cost differential is least between BHS build types. In the cases observed in Figure 64, and Figure 65, the building CAPEX cost delta between BHS types is £1,133,206 with the short haul BHS solution, whereas it is £1,661,658 with the long haul BHS solutions[110]. This in turn reduces the WLCC NPV delta in part, witnessed between manual, semi-automated, and fully automated BHS solutions. If the WLCC NPV delta margin between the BHS type solutions is smaller so it follows that when the high and low CAPEX factor sensitivities are applied this will then more easily change the WLCC ranking position.

[110] Note: This is true for base case test sensitivity scenario processing 2340bags/hour

One must remember that the WLCC NPV is also a product of operating cost, and also that there are significantly large cost differentials in the BHS equipment costs that are selected by the model. These variables are taken into account in this analysis of the WLCC NPV ranking.

Figure 64: Report A: Short haul only BHSs for 2340 bags/hour throughput input parameters

Code C & D (short haul) aircraft per hour	13
Code E Plus (long haul) aircraft per hour	0
Country CAPEX factor	0.59
Staff cost factor	0.59
Inflation rate per annum	3% PA
Staff work/build rate	2bags/minute
Output	
BHS Capacity/Demand	2340 Bags/Hour
BHS CAPEX (Option A: Fully Automatic BHS)	£9,001,527
BHS CAPEX (Option B: Semi-automatic BHS)	£8,366,316
BHS CAPEX (Option C: Manual BHS)	£8,083,843
Building CAPEX (Option A: Fully Automatic BHS)	£10,175,703
Building CAPEX (Option B: Semi-automatic BHS)	£9,954,325
Building CAPEX (Option C: Manual BHS)	£9,042,497
BHS OPEX (2020) - (Option A: Fully-automatic BHS)	£5,595,303
BHS OPEX (2020) - (Option B: Semi-automatic BHS)	£5,793,987
BHS OPEX (2020) - (Option C: Manual BHS)	£5,793,987
BHS & Building Whole Life Cycle Cost (Option A: Fully Automatic BHS)	(£24,926,324.)
BHS Whole Life Cycle Cost (Option B: Semi-automatic BHS))	(£22,913,271.)
BHS Whole Life Cycle Cost (Option C: Manual BHS)	(£23,256,412.)
BHS Area Required (Option A: Fully Automatic BHS)	3,219 m2
BHS Area Required (Option B: Semi-automatic BHS)	3,158 m2
BHS Area Required (Option C: Manual BHS)	3,033 m2
Recommended Solution (WLCC NPV)	Semi-automatic BHS

Figure 65: Report B: Long haul only BHSs for 2340 bags/hour throughput input parameters

Code C & D (short haul) Aircraft Per Hour	0
Code E Plus (long haul) Aircraft Per Hour	5
Cost Per Bag Processed	1
Country CAPEX Factor	0.59
Staff Cost factor	0.59
Inflation Rate %	3% PA
Staff work/build rate	2bags/minute
BHS Capacity/Demand	2340
Output	
BHS CAPEX (Option A: Fully Automatic BHS)	£8,609,207
BHS CAPEX (Option B: Semi-automatic BHS)	£7,973,997
BHS CAPEX (Option C: Manual BHS)	£7,934,830
Building CAPEX (Option A: Fully Automatic BHS)	£7,295,433
Building CAPEX (Option B: Semi-automatic BHS)	£7,074,055
Building CAPEX (Option C: Manual BHS)	£8,735,713
BHS OPEX (2020) - (Option A: Fully Automatic BHS)	£5,479,666
BHS OPEX (2020) - (Option B: Semi-automatic BHS)	£5,733,800
BHS OPEX (2020) - (Option C: Manual BHS)	£5,733,800
BHS & Building Whole Life Cycle Cost (Option A: Fully Automatic BHS)	(£20,168,264)
BHS Whole Life Cycle Cost (Option B: Semi-automatic BHS))	(£18,155,210)
BHS Whole Life Cycle Cost (Option C: Manual BHS)	(£22,197,085)
BHS Area Required (Option A: Fully Automatic BHS)	2,350 m^2
BHS Area Required (Option B: Semi-automatic BHS)	2,289 m^2
BHS Area Required (Option C: Manual BHS)	2,930 m^2
Recommended Solution (WLCC NPV)	Semi-Automatic BHS

Table 10, and Table 11 show no change in ranking when the sensitivities factors are applied. The introduction of long haul traffic reduces the impact of the test sensitivities when they are applied in the experiments.

With reference to Table 10 it is apparent that when processing only long haul traffic, and the experiment sensitivities are applied, that this did not change the WLCC NPV ranking of the BHS solution types. Similarly it can be observed in Table 11 that when a 50% component of short haul traffic is included, and the experiment sensitivities are applied that the result is that these had no impact upon the resultant WLCC NPV rankings.

Table 10: Effect of test sensitivities upon BHS WLCC NPV relative to base conditions for long haul traffic

		WLCC NPV Ranking	
Sensitivity	First place Lowest	Second place	Third place Highest
Base	Semi-automatic	Fully automatic	Manual
High CAPEX	Semi-automatic	Fully automatic	Manual
Low CAPEX	Semi-automatic	Fully automatic	Manual
High OPEX	Semi-automatic	Fully automatic	Manual
Low OPEX	Semi-automatic	Fully Automatic	Manual
High inflation	Semi-automatic	Fully automatic	Manual
Low inflation	Semi-automatic	Fully automatic	Manual
High staff loading rate	Semi-automatic	Fully automatic	Manual
Low staff loading rate	Semi-automatic	Fully automatic	Manual

Table 11: Effect of test sensitivities upon BHS WLCC NPV relative to base conditions for long / short haul mix of traffic

		WLCC NPV Ranking	
Sensitivity	First place Lowest	Second place	Third place Highest
Base	Semi-automatic	Fully automatic	Manual
High CAPEX	Semi-automatic	Fully automatic	Manual
Low CAPEX	Semi-automatic	Fully automatic	Manual
High OPEX	Semi-automatic	Fully automatic	Manual
Low OPEX	Semi-automatic	Fully Automatic	Manual
High inflation	Semi-automatic	Fully automatic	Manual
Low inflation	Semi-automatic	Fully automatic	Manual
High staff loading rate	Semi-automatic	Fully automatic	Manual
Low staff loading rate	Semi-automatic	Fully automatic	Manual

7.8 Chapter summary

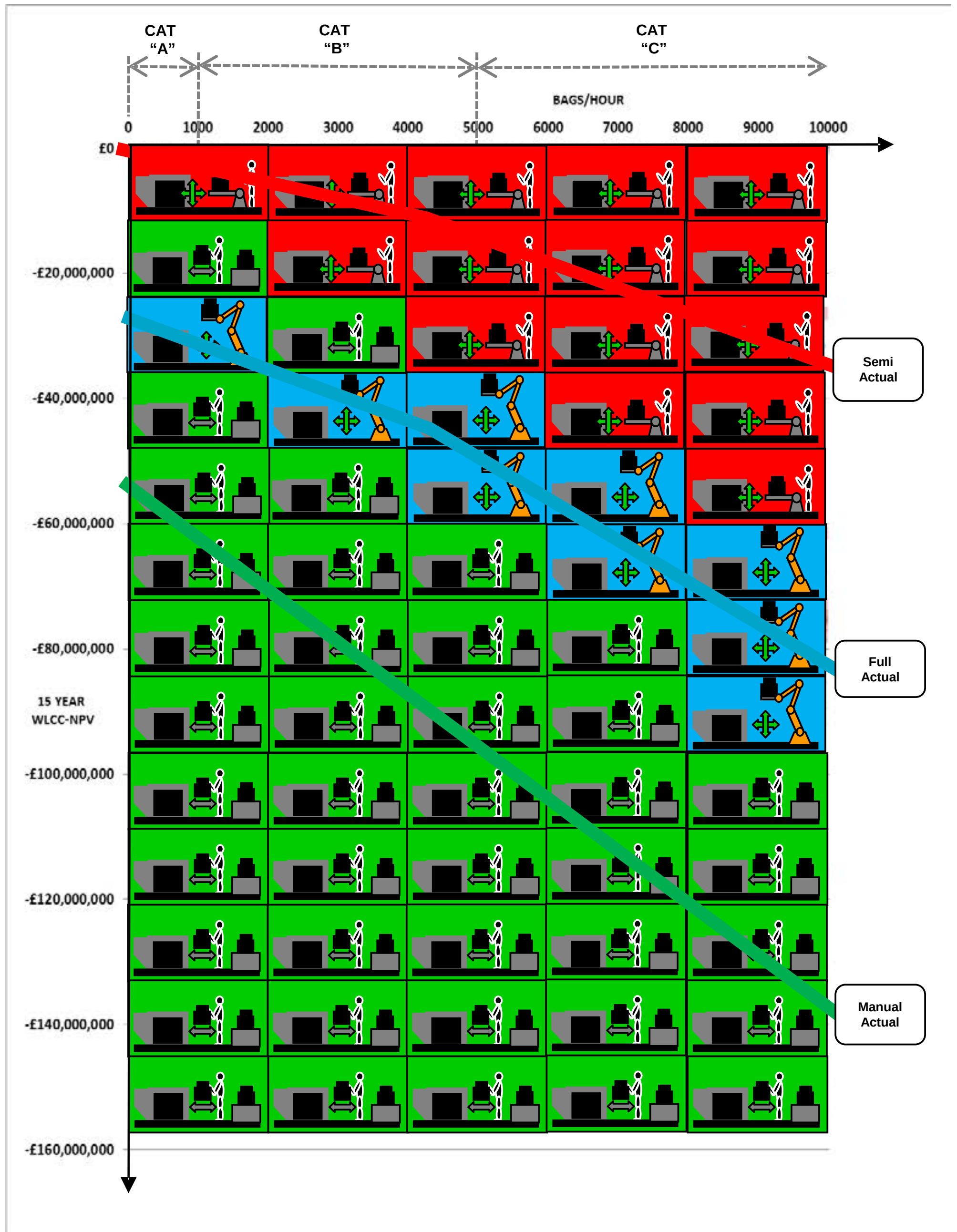
It can be seen in this Chapter that the ranking position of the various BHS solutions does change as the model is subjected to different test sensitivities. The results show that the CAPEX and OPEX values will naturally change as the various test sensitivities are applied, which in turn lead to WLCC NPV changes, which are obviously of prime importance; it is equally significant to note the relative change that can occur in WLCC NPV ranking when the test sensitivities are applied, which is outlined in Table 9, Table 10, and Table 11. The WLCC NPV of all of the test sensitivities has been captured in the scatter diagram seen in Figure 63; this contains the essential poly line plots for each of the BHS solution types.

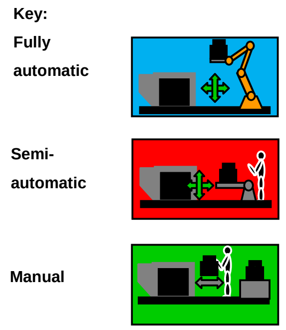
At the start of the PhD research stage an estimate was made as to where to place the three BHS flight build technology groups, within the framework of a bags/hour vs

WLCC NPV metric; this unsubstantiated view was defined and recorded within “Figure 2: Pre-investigation industry view”. Following the conclusion of the PhD study Figure 2 should be replaced by the factually correct Figure 66. This shows the placement of three flight build technologies within a technology capacity resolution of 2000bags/hour processing capability, and a 15 year life period WLCC NPV financial resolution of GB£12,500,000.

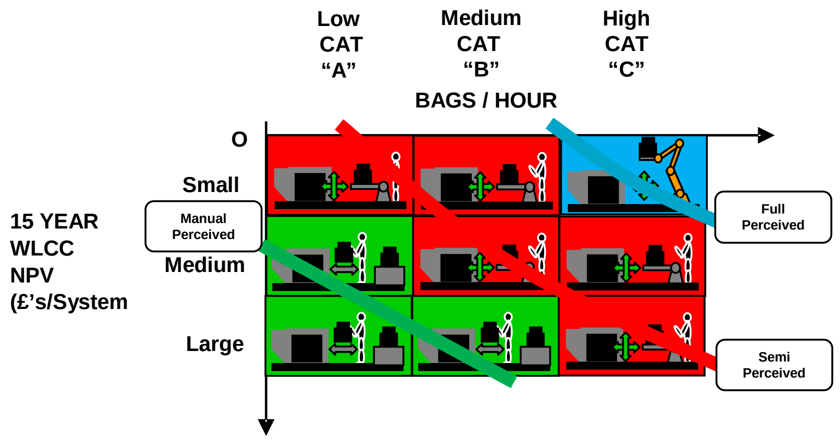
Figure 66: Actual model graphical output conclusion[111]

ACTUAL RESULTS: 15 YEAR WLCC NPV vs BAGS/HOUR





INDUSTRY PERCEIVED RESULTS: 15 YEAR WLCC NPV vs BAGS/HOUR



[111] This figure shows all the WLCC NPV results using all of sensitivities scenarios denoted in the following input parameters as is the accurate equivalent to that estimated in Figure 2.
19% - 59% - 110% CAPEX factor applied
19% - 59% - 110% OPEX factor applied
1% - 3% - 7% inflation applied
1 – 2 – 3 bags/min loading rate

8. CONCLUSION

8.1 Thesis conclusions

This Chapter draws a conclusion from the literature review. The influence that the assumptions, stated in Section 5.5, had upon the results obtained from the model is also examined, and concluded. Finally this Chapter draws conclusions on the main observations noted in Chapter 7, and suggests further alternative avenues of investigation that could be of benefit to the aviation industry.

8.1.1 Uniqueness of research aim

It is clear from the literature review explained in Chapter 2 that this PhD is indeed unique, and the area of investigation detailed herein have not previously been examined or documented before the submission date of this thesis.

The findings denoted herein shall add considerable value to the aviation industry that are about to develop a BHS, as this PhD provides clear commercial ranking of the BHS solution types that are on offer to airport operators. It also provides the airline industry a detailed appreciation of what happens to the WLCC NPV ranking, when the test sensitivities are applied.

8.1.2 Commercial ranking of BHS build types

With reference to Figure 63, the WLCC NPV scatter diagram, and the poly line plots for each BHS solution, it is clear that when simultaneously taking into account all test sensitivities, that the semi-automated BHS WLCC NPV is ranked the least expensive solution for airports, and airlines to select. For category A, B and C BHSs, between zero and 4000bags/hour, the manual BHS solution type is ranked the second cheapest WLCC NPV, and the fully automatic BHS solution type is ranked third, the most expensive solution type. These second and third rankings are switched when the BHS is required to process more than 4000bags/hour.

8.1.3 Commercially best BHS for short haul operation

From Table 9 it can be seen that for short haul operations, that the semi-automatic build BHS solutions are more likely to provide the lowest WLCC NPV. The manual BHS solutions generally have the second cheapest WLCC NPV. The fully automatic BHS solution type will always be the most expensive.

8.1.4 Commercially best BHS for long haul operations

From Table 10 it can be seen that for long haul operations, that the semi–automatic build solution will always produce the lowest WLCC NPV. The fully automatic BHS solution type is the second cheapest always, and the manual build BHS type will always be the most expensive.

8.1.5 Commercially best BHS for long haul / short haul mix operations

From Table 11 it can be seen that for long haul / short mix operations, that the semi-automatic build BHS solutions will always produce the lowest WLCC NPV. Fully automatic BHS are the second cheapest from a WLCC NPV perspective, and the manual BHS are the most expensive.

8.2 The Robotic vs RTT staffing comparison

This section defines the general staffing level efficiencies that can be seen with the deployment of fully automatic build, and semi-automatic flight build technologies for a given set of input demand flow rates of baggage.

Table 12: Robotic and RTT component staffing levels vs demand (Bags/Minute)

Component Ref.	Flight Build Unit	Unit Capacity Bags/Min	Staff Per Unit	Demand Bags/Min			
				10.00	50.00	75.00	100.00
				Number of staff Required			
g1	Robots	4.00	0.50	1.25	6.25	9.38	12.50
g2	RTT	6.00	1.00	1.67	8.33	12.50	16.67

It can be seen from Table 12 that the number of staff needed to supervise, and top up the robotic fully automatic (component g1) build is always less than the staff needed to operate the semi-automated RTT (component g2). This factor has been taken into account within the model, and considered within the overall OPEX, and WLCC NPV calculations. Whilst the robotic BHSs require less staff, it is the BHS solutions that contain the RTT component g2 that generally provide a lower WLCC NPV. This affect is attributed to:

(i) The additional quantity of supporting conveyors needed to make the Robotic solution function;

(ii) The difference in area between the two types of technology, and the resultant affect this has upon building capital cost, and building OPEX;

(iii) The elevated capital cost of the Robotic component g1 verses g2. The robotic component g1 is approximately seven times more expensive than the RTT component g2.

The key findings contained within the thesis are based on the fundamental assumption that the RTT operators work consistently at the rate stipulated within Chapter 3. In reality staff performance will vary considerably from day to day, and from operator to operator; the robotic fully automated build component is a component with a known constant performance. That performance can be considered to be a constant 24 hours a day seven days a week.

8.3 Bag charges

Throughout all of the experiments carried out, a nominal £1 per bag processed, bag charge was levied, albeit varied by the OPEX factor. The £1/bag processing charge will vary in reality, and often airports may try to recover the actual full OPEX running costs of the BHS using this charge. Since the WLCC NPV cost is extremely sensitive to variations in bag charge, changing the bag charge would have a significant impact on the resultant WLCC NPVs notified within the results seen in Appendix H.

8.4 Scatter diagram limitations

The scatter diagram seen in Figure 63 is a good reference for airports, and for airlines that are about to embark on developing a BHS, and a baggage system building. It can be used to aid the capital planning process where the correct (quarter 4 2011) prices of the various technologies are defined. Furthermore the 15 year WLCC NPVs provide an insight into the 15 year combined capital and operational costs.

It should be noted that the scatter diagram should be read with care. The poly line plots, explained in Chapter 7, are a summation of all of the test sensitivities. If an airport operator, or an airline have a clear understanding of the regional test sensitivity factors that are present at the developing airport, then the reader of this thesis should refer to the results, noted in Chapter 6, that were obtained using airport specific factors that best match the test sensitivities factors. This will lead the airport operator or airline to select the most effective solution, taking into account the closest match of test sensitivities.

8.5 Health and safety issues

The aim of this thesis is to concentrate on the commercial aspects that relate to the performance, and ultimate WLCC NPV of the three flight build technologies. This PhD does not address the health and safety issues that are being presented by national bodies for the loading of baggage into ULD and baggage cart containers (e.g. mandates set by the UK Health and Safety Executive etc...). Irrespective of the commercial position of the three flight build technologies, airports, airlines, and ground handling agents maybe required to install at least the semi-automated BHS technologies, on the basis that these technologies can reduce injuries to operators. There are alternative semi-automated technologies that exist, other than the stated RTT LONGREACH™ mechanized bag build component g2 unit.

The semi-automated technology assessed in this PhD overall is ranked as the most commercially viable solution. This technology may become the minimum entry level technology for airports to use to build flights in the not too distant future, and can provide positive health and safety characteristics for the operators that use it. That said the literature review did not reveal any studies done by airports to assess the health and safety performance of semi-automated flight build technologies that can be used for prolonged periods. This would be a useful separate investigation.

8.6 Thesis recommendations

This section recommends what airport operators, airlines, and ground handling agents should do with the findings of this thesis, and what further studies could be considered.

8.6.1 Generate 2D and 3D design models

The data from the model could be developed into a commercial design model linked to a computer aided design software interface. This would allow the model to generate not only commercial, and technical specifications, as seen in Appendix H, but also to create accurate 2D, and 3D drawings of the proposals for use within architectural, and engineering design plans.

8.6.2 Break-even analysis

It could be useful to airlines, and to airport operators to provide an extended set of results that show the consequence of changing the bag charge from the stated nominal £1/bag processed rate. This would likely not change the commercial rankings of the alternative BHS build types, and arguably add any further value to meeting the PhD aim, but would show the User Group, and the Specialist Group the breakeven positions, and the true bag charge needed for any specific BHS development.

8.6.3 Scatter diagram and actual graphical output conclusion

Airport operators and airlines that are about to embark on developing a BHS should first refer to the results contained in Chapter 6, the scatter diagram seen in Figure 63, and the actual graphic conclusion diagram seen in Figure 66. This information shall inform which technologies best matches the commercial, and operational requirements of that airport location, for any given size of airport BHS development, IATA (2004) Category A, B, and C BHSs.

The scatter diagram (Figure 63) and the actual graphic conclusion diagram seen in (Figure 66), will be used both the User Group, and the Specialist Group to determine the most cost effective BHS solution to select for the specific location. From Figure 66 it can be seen that generally the lowest WLCC NPV will be achieved with the semi-automatic BHSs, this will lead airports to use this technology more and more; the ramifications of this will be that this technology will reduce staff levels and in turn operating costs for the User Group.

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X. APPENDICES

APPENDIX A PROCESS DEFINITION

A1 Referenced BHS processes and rules

This Appendix provides an explanation of the processes, and rules that are referenced, and programmed into the model software. The detail contained herein defines the overall process blocks that are present within manual, semi-automatic, and fully automatic baggage handling systems, and the equipment selection and utilisation rules that are present within the model.

Figure 67, Figure 70, and Figure 73 define the overview level design process maps that relate to the manual, semi-automatic and fully automatic build BHS design that are referenced within the assembly environment worksheet of the model.

Figure 68, Figure 71, and Figure 74 define the detailed level design process maps that relate to the manual, semi-automatic and fully automatic build BHS design that are referenced within the assembly environment worksheet.

Both the overview and detailed level process maps have been derived from processes seen within Chapter U of the IATA (2004) best practice documentation, and process maps obtained from BHS consultants and suppliers. These companies have produced many of the BHSs that have been put into operation over the last 30 years.

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APPENDIX A PROCESS DEFINITION CONTINUED

The overview level process maps explain the main building blocks that are contained within the manual, semi-automatic, and fully automatic BHSs. These blocks include (i) check-in, (ii) delivery, (iii) HBS, EBS, and (iv) flight sortation. The overview level process maps also define the equipment and bag hall people groups that are incorporated within the model, such as (i) baggage conveyors; (ii) ULD storage systems, (iii) Power systems, (iv) IT, (v) handling agent, and (vi) support steelwork systems that are employed.

The detailed level process maps explain, for the manual, semi-automatic and fully automatic BHSs, the relationship between the process blocks, when deployed in series, and when they are deployed in parallel. In particular the detailed level process blocks explain the contingency routes, and links that are needed between the series and parallel process blocks. These links are then grouped into zones A, B and C as defined in Figure 68, Figure 71, and Figure 74.

The assembly environment worksheet assembles the correct quantity of components (Figure 8 through to Figure 25 inclusive) that are needed to construct a manual BHS, semi-automated BHS, and a fully automated BHS. Each type (manual/semi-automatic/fully automatic) of BHS is constructed differently. The quantity and type of components that are used within each zone are specified in the tables provided in Figure 69, Figure 72, and Figure 75.

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APPENDIX A PROCESS DEFINITION CONTINUED

Zone A defines the components needed between the Check-in and the Delivery line process blocks.

Zone B defines the components needed between the Delivery line and HBS process blocks.

Zone C defines the components needed between the HBS block and the Flight sortation process blocks.

A2 Manual BHS rules set example

For example, in Figure 17 the component e7 (Merge VSU) unit is used in zones A, B and C. The model needs to determine the quantity of e7 units in these zones to complete that part of the design. In zone A the quantity of Merge VSU conveyors needed between the check-in process block, and the delivery line process block is defined by the rule: If the number (#) of delivery lines “b1” is less than 2 then the number (#) of merge VSUs needed is equal to 0. If the number of delivery lines is 2 or more then the quantity of merge VSUs needed is equal to the number (#) of delivery lines present minus the numeric value 1. So if the quantity of delivery lines equals two then the number VSUs needed in zone A equal one.

Figure 17 defines the BHS rules for the use of components e7 (Merge VSU), e9 (Divert VSU), e10 (Indexing), e11 (Sortation induct), e12 (Sortation loop) and f2 (ULD Powered Rollerbed) in the interconnecting zones A, B and C within a manual BHS.

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APPENDIX A PROCESS DEFINITION CONTINUED

A3 Semi-automatic BHS rules set example

For example within Figure 19 the component e10 (Indexing conveyor assembly) is used in zones A, B, and C.

In zone B the quantity of e10 units is defined by the rule that for each HBS line (component d1) there is a need to provide five e10 indexing conveyor assemblies.

Figure 72 defines the BHS rules for the use of components e7 (Merge VSU), e9 (Divert VSU), e10 (Indexing), e11 (Sortation induct), e12 (Sortation loop), and f2 (ULD Powered Rollerbed) in the interconnecting zones A, B and C within a semi-automatic BHS.

A4 Fully automatic BHS rules set example

For example the component f2 (ULD Powered Rollerbed) is not used in zones A and B, but is used in zone C only.

In zone C the quantity of f2 units (three ULD sub assembly) that are required within the model is defined by the rule that for every g1 (Automatic ULD Build) robot assembly, there is a need to provide three ULDs holding spaces, coupled to five ULD lead in spaces, and five system exit ULD spaces. In addition to this to calculate the total quantity of ULDs needed, described by the component f2, the equations (14, 15 and 16) are used. This, in part, states that for every Code C flight processed per hour, there is a need to provide 10 ULDs, and for every Code F flight processed per hour, there is a need to provide 20 ULDs.

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APPENDIX A PROCESS DEFINITION CONTINUED

Figure 75, defines the BHS rules for the use of components, e7 (Merge VSU), e9 (Divert VSU), e10 (Indexing), e11 (Sortation induct), e12 (Sortation loop), and f2 (ULD Powered Rollerbed) in the interconnecting zones A, B and C within a fully-automatic BHS.

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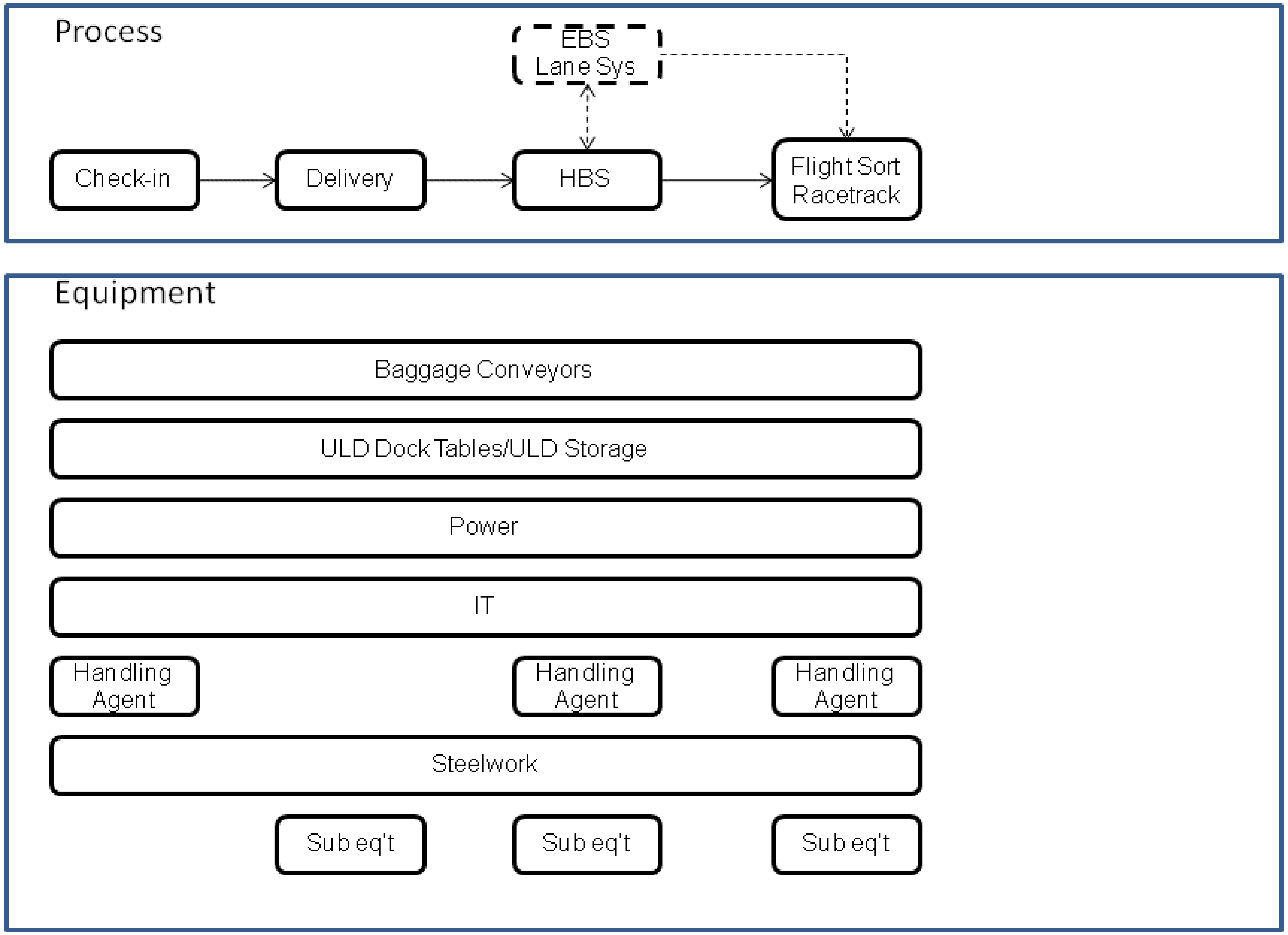
APPENDIX A PROCESS DEFINITION CONTINUED

Figure 67: Process Maps Overview Level: Manual System



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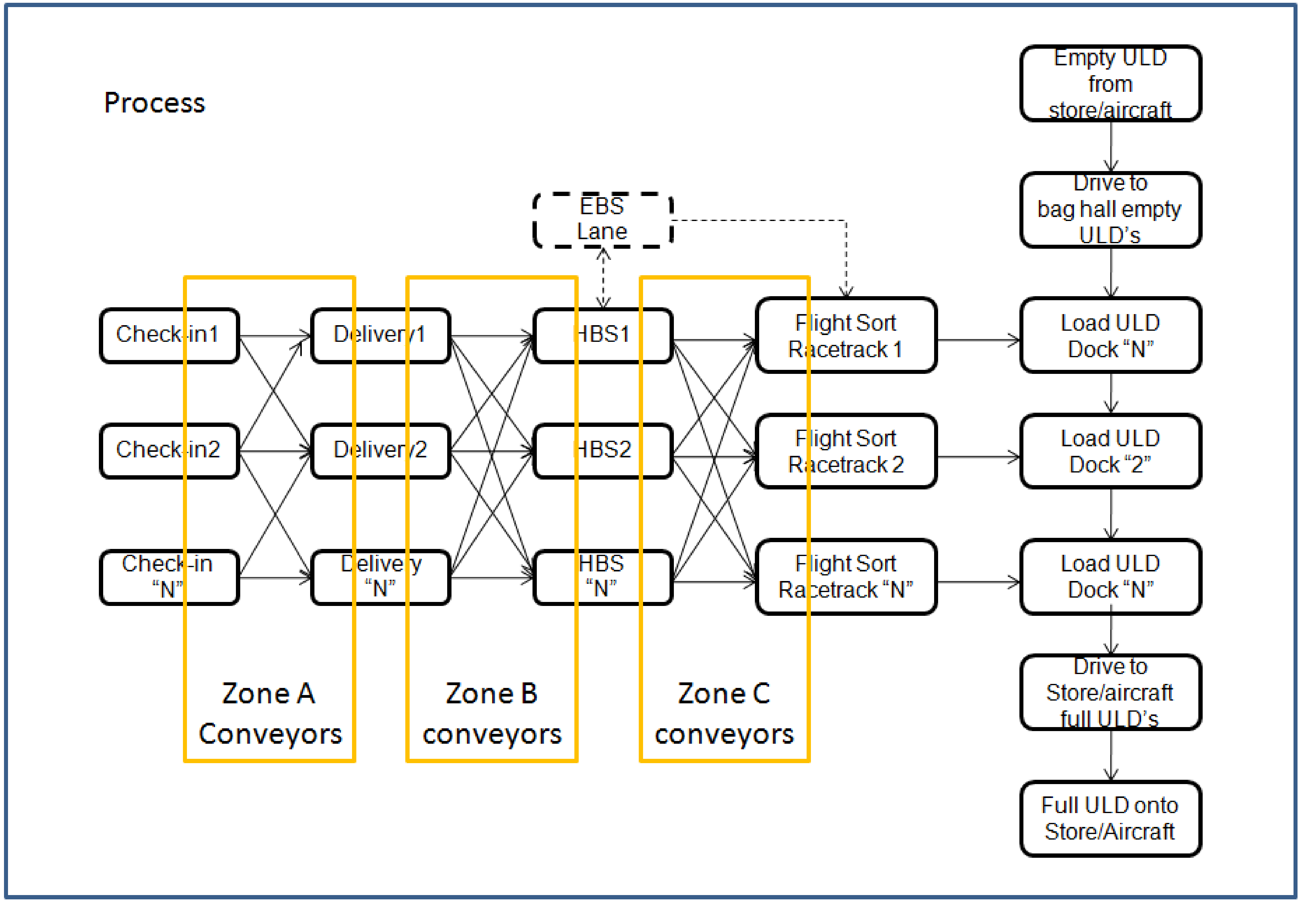
APPENDIX A PROCESS DEFINITION CONTINUED

Figure 68: Process Maps Detailed Level: Manual System



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APPENDIX A PROCESS DEFINITION CONTINUED

Figure 69: Manual build Link conveyor supply rules

Flight sortation	Description	Zone A conveyors Between check-in and delivery lines	Zone B conveyors Between delivery lines and HBS	Zone C conveyors Between HBS and Flight sortation
e7	Merge VSU	If # of delivery lines "b1" < 2 then # of merge VSU needed = 0, else # or merge VSU needed = # of delivery lines present minus 1	If # of HBS "d1" < 2 then # of merge VSU needed = 0, else # or merge VSU needed = # of HBS lines present minus 1	If # of racetracks "e3" < 2 then # of merge VSU needed = 0, else # of merge VSU needed = # of racetracks present minus 1
e9	Divert VSU	If # of delivery lines "b1" < 2 then # of divert VSU needed = 0, else # or divert VSU needed = # of delivery lines present minus 1	If # of HBS "d1" < 2 then # of divert VSU needed = 0, else # or divert VSU needed = # of HBS lines present minus 1	If # of racetracks "e3" < 2 then # of divert VSU needed = 0, else # of divert VSU needed = # of racetracks present minus 1
e10	Indexing	Each Delivery line "b1" will have 5 Queuing indexing conveyors	Each HBS line "d1" will have 5 Queuing indexing conveyors	Each racetrack "e3" will have 5 Queuing indexing conveyors
e11	Sortation induct	Each Delivery line "b1" will have 0 sortation induct conveyors	Each HBS line "d1" will have 0 sortation induct conveyors	Each racetrack "e3" will have 1 Queuing induct conveyor
e12	Sortation loop	Each Delivery line "b1" will have 0 sortation loop conveyors	Each HBS line "d1" will have 0 sortation loop conveyors	Sortation loop length = 3m per lateral needed x # of laterals needed x both sides of loop (e.g. x2) plus Radius 5m turns.
f2	ULD Powered Rollerbed (1x2m rollerbed)	Not applicable	Not applicable	Storage Needed Code C 10ULDs/Flight Code F 20ULDs/Flight

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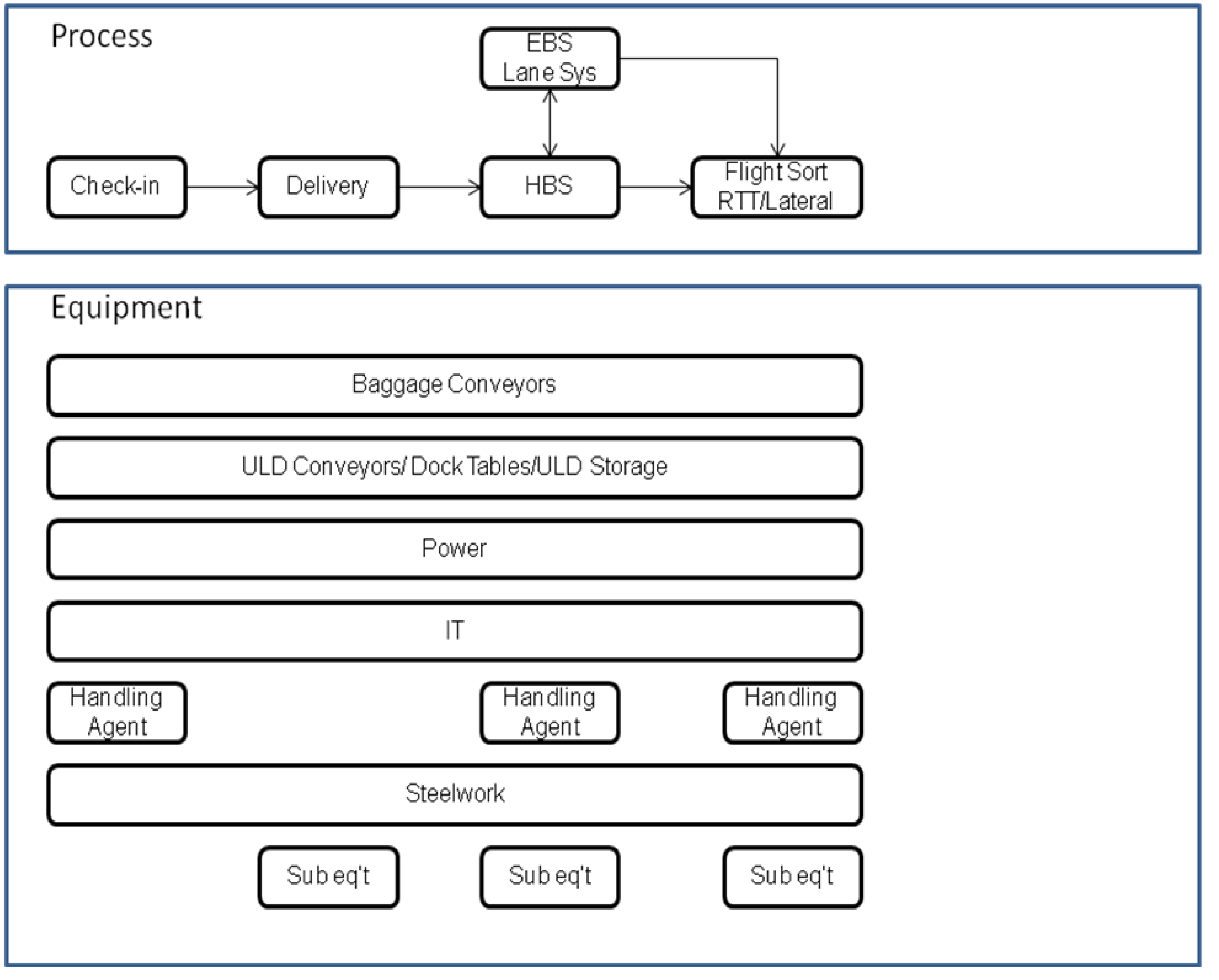
APPENDIX A PROCESS DEFINITION CONTINUED

Figure 70: Process Maps Overview Level: Semi-automated



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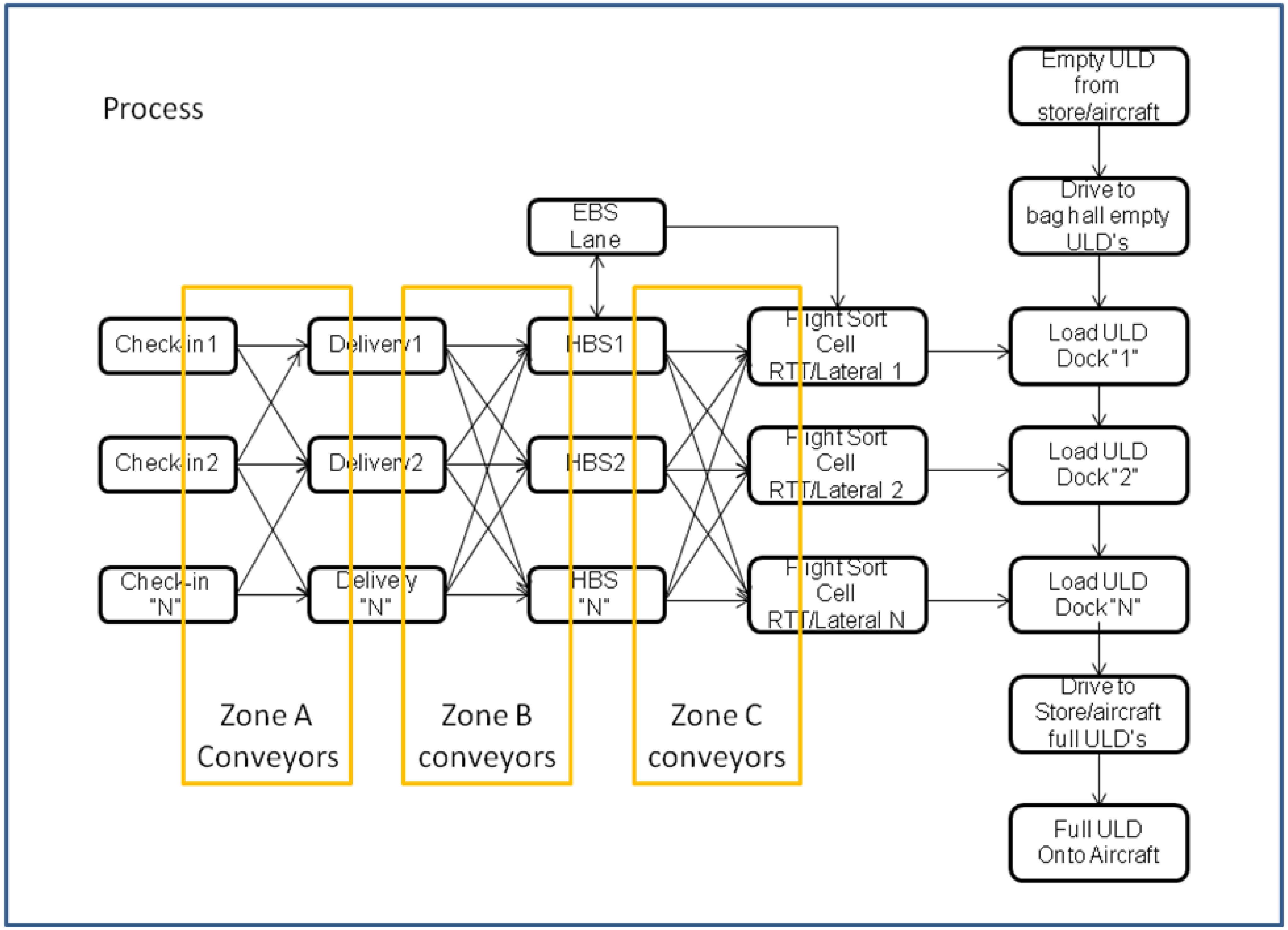
APPENDIX A PROCESS DEFINITION CONTINUED

Figure 71: Process Maps Detailed Level: Semi-automated



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APPENDIX A PROCESS DEFINITION CONTINUED

Figure 72: Semi-automated build Link conveyor supply rules

Flight sortation	Description	Zone A conveyors Between check-in and delivery lines	Zone B conveyors Between delivery lines and HBS	Zone C conveyors Between HBS and Flight sortation
e7	Merge VSU	If # of delivery lines "b1" < 2 then # of merge VSU needed = 0, else # or merge VSU needed = # of delivery lines present minus 1	If # of HBS "d1" < 2 then # of merge VSU needed = 0, else # or merge VSU needed = # of HBS lines present minus 1	If # of RTT "g2" < 2 then # of merge VSU needed = 0, else # of merge VSU needed = # of RTT present minus 1
e9	Divert VSU	If # of delivery lines "b1" < 2 then # of divert VSU needed = 0, else # or divert VSU needed = # of delivery lines present minus 1	If # of HBS "d1" < 2 then # of divert VSU needed = 0, else # or divert VSU needed = # of HBS lines present minus 1	If # of RTT "g2" < 2 then # of divert VSU needed = 0, else # of divert VSU needed = # of RTT present minus 1
e10	Indexing	Each Delivery line "b1" will have 5 Queuing indexing conveyors	Each HBS line "d1" will have 5 Queuing indexing conveyors	Each RTT "g2" will have 40 Bell Cell Preparation Queuing indexing conveyors
e11	Sortation induct	Each Delivery line "b1" will have 0 sortation induct conveyors	Each HBS line "d1" will have 0 sortation induct conveyors	Each RTT "g2" will have 1 Queuing induct conveyor
e12	Sortation loop	Each Delivery line "b1" will have 0 sortation loop conveyors	Each HBS line "d1" will have 0 sortation loop conveyors	Sortation loop length = 3m per RTT/lateral needed x # of RTT's needed x both sides of loop (e.g. x2) plus Radius 5m turns.
f2	ULD Powered Rollerbed (1x2m rollerbed)	Not applicable	Not applicable	For every RTT there is 2 ULDs spaces and 5 Lead in spaces and 5 exit spaces Total 12ULD/RTT Storage Needed Code C 10ULDs/Flight Code F 20ULDs/Flight

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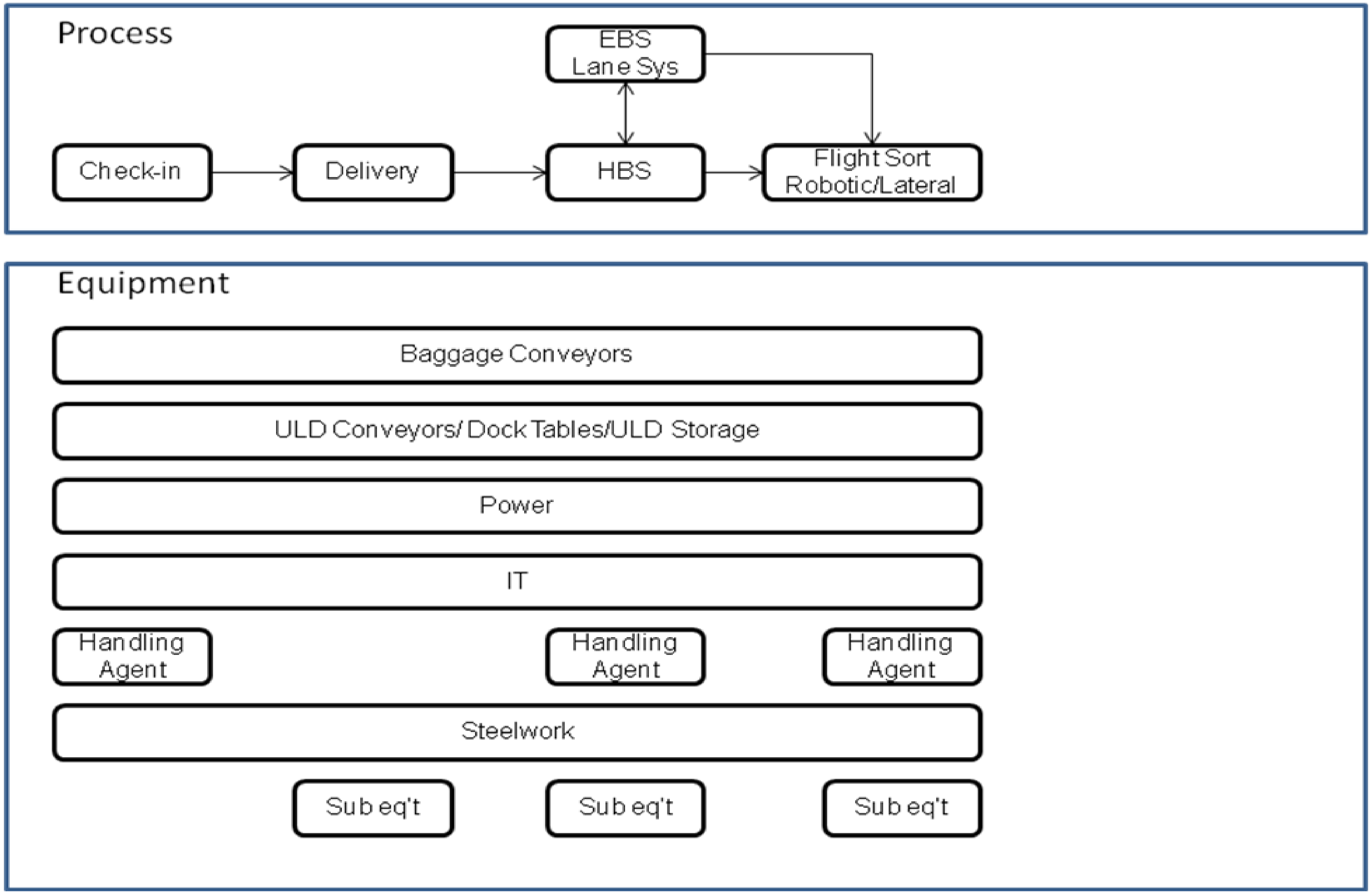
APPENDIX A PROCESS DEFINITION CONTINUED

Figure 73: Process Maps Overview Level: Fully automated



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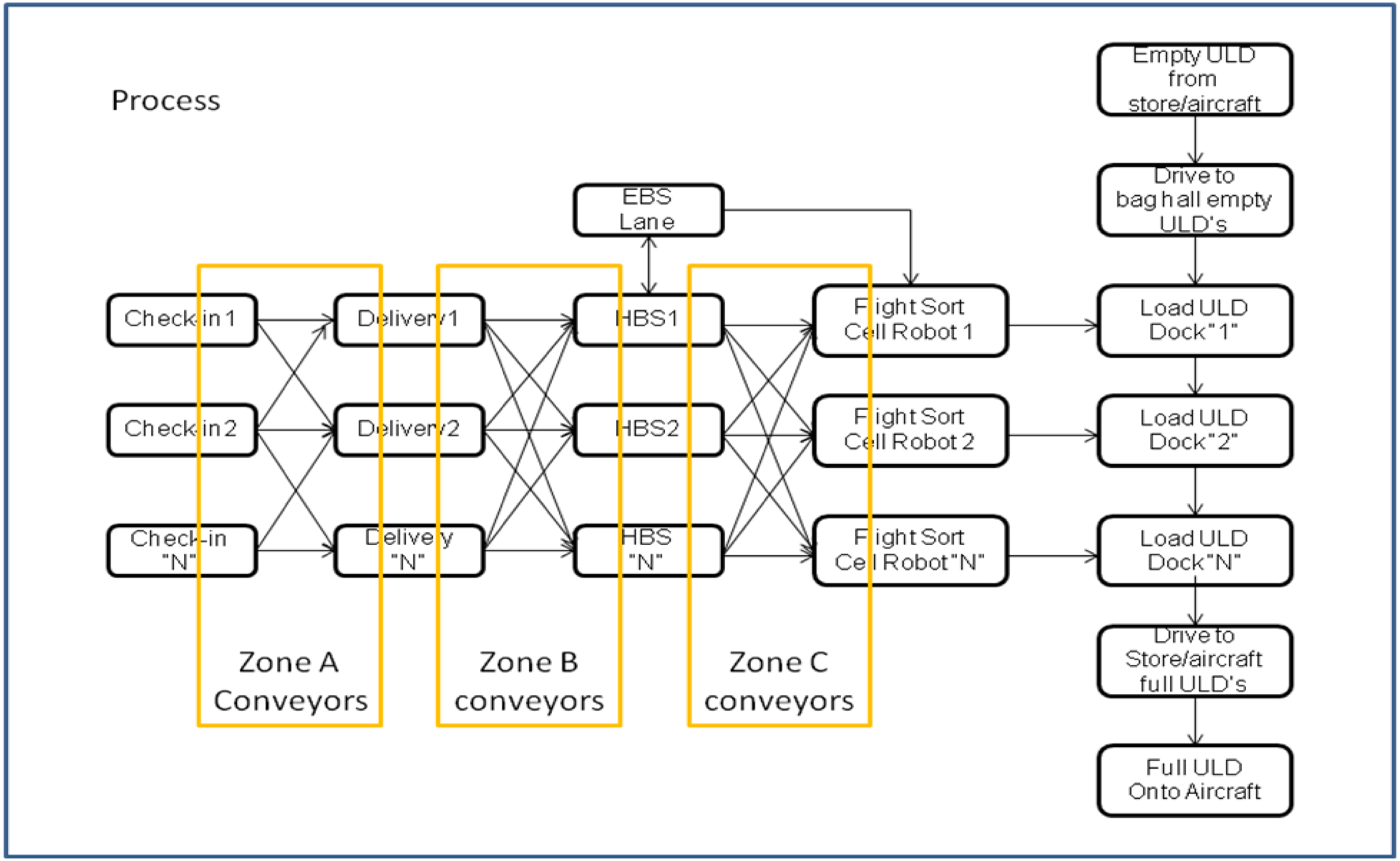
APPENDIX A PROCESS DEFINITION CONTINUED

Figure 74: Process Maps Detailed Level: Fully automated



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APPENDIX A PROCESS DEFINITION CONTINUED

Figure 75: Fully automated build Link conveyor supply rules

Flight sortation	Description	Zone A conveyors Between check-in and delivery lines	Zone B conveyors Between delivery lines and HBS	Zone C conveyors Between HBS and Flight sortation
e7	Merge VSU	If # of delivery lines “b1” < 2 then # of merge VSU needed = 0, else # or merge VSU needed = # of delivery lines present minus 1	If # of HBS “d1” < 2 then # of merge VSU needed = 0, else # or merge VSU needed = # of HBS lines present minus 1	If # of Robot “g1” < 2 then # of merge VSU needed = 0, else # of merge VSU needed = # of Robtos present minus 1
e9	Divert VSU	If # of delivery lines “b1” < 2 then # of divert VSU needed = 0, else # or divert VSU needed = # of delivery lines present minus 1	If # of HBS “d1” < 2 then # of divert VSU needed = 0, else # or divert VSU needed = # of HBS lines present minus 1	If # of Robots “g1” < 2 then # of divert VSU needed = 0, else # of divert VSU needed = # of Robots present minus 1
e10	Indexing	Each Delivery line “b1” will have 5 Queuing indexing conveyors	Each HBS line “d1” will have 5 Queuing indexing conveyors	Each Robot “g1” will have 40 Build Cell Preparation Queuing indexing conveyors
e11	Sortation induct	Each Delivery line “b1” will have 0 sortation induct conveyors	Each HBS line “d1” will have 0 sortation induct conveyors	Each Robot “g1” will have 1 Queuing induct conveyor
e12	Sortation loop	Each Delivery line “b1” will have 0 sortation loop conveyors	Each HBS line “d1” will have 0 sortation loop conveyors	Sortation loop length = 3m per Robot /lateral needed x # of Robot's needed x both sides of loop (e.g. x2) plus Radius 5m turns.
f2	ULD Powered Rollerbed (1x2m rollerbed)	Not applicable	Not applicable	For every Robot there is 3 ULDs spaces and 5 Lead in spaces and 5 exit spaces Total 12ULD/Robot Storage Needed Code C 10ULDs/Flight Code F 20ULDs/Flight

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APPENDIX B INPUT VARIABLES WORKSHEET

Output Data Calculated

Flight Schedule

Input Data

				5800	Pax/hour	
				6600	Bags/hour	
				0%	% Maximum Peaking Factor	
				£1.00	Bag Charge Per Bag Processed	
Item	Input Variables			Used Parameter	Units	Data Source
1	INPUT: Declared Bag to Pax Ratio (average Long Haul)			1.2	bags/pax	IATA: Airport Development Refference Manual Table C2-1
2	INPUT: Declared Bag to Pax Ratio (average Short Haul)			1	bags/pax	IATA: Airport Development Refference Manual Table C2-1
3	INPUT: Declared number of LH flights in peak hour			10	flights Long Haul/hour	
4	INPUT: Declared number of SH flights in peak hour			10	flights Short Haul/hour	
5	INPUT: Point A Aircraft Brakes on time LONG HAUL relative to STD			180	STD[minutes] long haul	
6	INPUT: Point A Aircraft Brakes on time SHORT HAUL relative to STD			60	STD[minutes] short haul	
7	INPUT: A-B (LONG HAUL) Unload FULL ULD – from inbound aircraft			22.5	CODE D Time [minutes]	
8	INPUT: A-B (SHORT HAUL) Unload FULL carts – from inbound aircraft			14	CODE C Time [minutes]	
9	INPUT: B-C Drive FULL ULD/carts from aircraft to baggage hall			5	Time [minutes]	
10	INPUT: C-D Unload FULL ULD/carts at arrivals / transfer input docks			1.5	Time [minutes]	
11	INPUT: E-F Drive FULL ULD's/carts to aircraft			5	Time [minutes]	
12	INPUT: F-G Load FULL ULD's onto aircraft Long Haul			22.5	CODE D Time [minutes]	
13	INPUT: F-G Load FULL cart contents onto aircraft Short Haul			14	CODE C Time [minutes]	
14	INPUT: Declared Pax Load/Flight (Long Haul)			400	Pax/Long haul flight	
15	INPUT: Declared Pax Load/Flight (Short Haul)			180	Pax/Short haul flight	
16	Year Build / System Completed		N/A	2011	Year	Alex Bradley
16a	Calculated inflation factor		N/A	1.3387	Factor	Source: UK Office for National Statistics
17	**INPUT CAPEX FACTOR**		CAPEX FACTOR	0.59	Factor	IATA: Airport Development Refference Manual
18	**INPUT OPEX FACTOR**		OPEX FACTOR	0.59	Factor	IATA: Airport Development Refference Manual (CAPEX Rates used as OPEX factor rates)
19	Building Construction Type Used	Regional Terminal Building		2,209	£/m²	IATA: Airport Development Refference Manual (Section D5 in 2003 prices)
20		International Terminal Building		3,480	£/m²	IATA: Airport Development Refference Manual (Section D5 in 2003 prices)
21		Steel frame / cladding		3,254	£/m²	Real airport cost plan (adjusted)
22		Average actual rate used		£2,981	£/m²	Calculated average
23	Automation Loading Technology	Robotics Build Rate		4	Bags/Min	Alex Bradley AMS site visit to robotic BHS
24		Manipulator Build Rate		6	Bags/Min	Alex Bradley Video of RTT in operation
25		BHS Operator Build Rate		2	Bags/Min	IATA: US Carrier / Canadian Carrier
26		Load safe		3	Bags/Min	Technical consultant: Mike Read
27	Heating, ventilation and lighting, annual rate per annum	Building	£12	12	£/m2/annum	JBC: John Briggs Consultancy (Bag systems and building OPEX consultant Nov 2011)
28	Maintenance (Building), annual rate per annum	Building	£54	54	£/m2/annum	JBC: John Briggs Consultancy (Bag systems and building OPEX consultant Nov 2011)

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APPENDIX C EQUIPMENT DBASE WORKSHEET

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	O	P	Q	R	S	T	U	V	W	X	Y
Ref ID	System Function	Sub System Technology	Length	Speed (m/s)/Rate	Window length	Time to move window	UNIT CAPACITY BAGS/MIN.	Unit Plan Area m^2	Actual Power (kW)	Efficiency Factor	Rated Installed Power (KW)	Simultaneous Diversity Factor	Actual Power Consumption (KW)	Allowance for Additional Demand	Resultant Power Consumption	Running Hours per Annum	Energy Consumption (KWh)	Unit Cost (£ per KWh)	Energy Cost	Maintenance Cost	KEY OUTPUT Unit Running OPEX Cost UK 2011	OPEX Running Cost £ PA	Capital Cost £ / Unit	Source Date	Freight Volume m^3	KEY OUTPUT Corrected 2011 Day Price £
															1.10											
a1	Check-in	Conventional Conveyor (3x1.2m assembly)	3.6	0.0134	1.2	89.55	0.67	5.40	2.25	0.8	2.8125	0.75	2.11	0.10	2.32	6570.00	15244.45	0.16	2446.73	£3,000.00	£ 5,446.73	£2,365.20	£12,125	2009	11	£ 13,481.34
b1	Delivery	Collector Belt (1x20m)	20	0.5000	1.2	2.40	25.00	30.00	5	0.80	6.25	0.75	4.69	0.10	5.16	6,570.00	33876.56	0.16	5437.19	£ 1,500.00	£ 6,937.19	£ 5,256.00	£6,185	2009	9.975	£ 6,877.08
b4		Powered Belt Curve	2.5	0.5000	1.2	2.40	25.00	4.91	1.5	0.80	1.875	0.75	1.41	0.10	154.69%	6,570.00	10162.97	0.16	1631.16	£ 2,000.00	£ 3,631.16	£ 1,576.80	£28,600	2009	6	£ 31,800.23
c1	Early Baggage Store	Conveyor Lane Q conveyors (1x1.2m)	1.2	1.0000	1.2	1.20	50.00	1.80	1.1	0.80	1.375	0.75	1.03	0.10	113.44%	6,570.00	7452.84	0.16	1196.18	£ 1,500.00	£ 2,696.18	£ 1,156.32	£3,000	2011		£ 3,000.00
d1	Hold Baggage Screening	Standard 2 Level 1 Unit	5	0.5000	1.5	3.00	20.00	25.00	7.5	0.80	9.375	0.75	7.03	0.10	773.44%	6,570.00	50814.84	0.16	8155.78	£ 21,000.00	£ 29,155.78	£ 7,884.00	£250,000	2011		£ 250,000.00
d2		Standard 2 Level 3 Unit	22.5	0.1000	1.5	15.00	4.00	33.75	7.5	0.80	9.375	0.75	7.03	0.10	773.44%	6,570.00	50814.84	0.16	8155.78	£ 54,000.00	£ 62,155.78	£ 7,884.00	£750,000	2011		£ 750,000.00
d3		Standard 2 Level 2 Workstation	1	0.0750	1.5	20.00	3.00	1.00	0.1	0.80	0.125	0.75	0.09	0.10	10.31%	6,570.00	677.53	0.16	108.74	£ 100.00	£ 208.74	£ 105.12	£15,000	2011		£ 15,000.00
e1	Flight Sortation	Flight Lateral (1x28m)	28	0.2000	1.2	6.00	10.00	210.00	6.6	0.80	8.25	0.75	6.19	0.10	6.81	6,570.00	44717.06	0.16	7177.09	£ 1,000.00	£ 8,177.09	£ 6,937.92	£13,395	2009	15.1875	£ 14,893.85
e3		Flight Racetracks (1x40m length unit)	42	0.2000	1.2	6.00	10.00	504.00	2.2	0.80	2.75	0.75	2.06	0.10	2.27	6,570.00	14905.69	0.16	2392.36	£ 5,000.00	£ 7,392.36	£ 2,312.64	£19,761	2009	15.05655	£ 21,972.18
e7		Merge VSU	3	1.0000	1.2	1.20	50.00	4.50	1.1	0.80	1.375	0.75	1.03	0.10	1.13	6,570.00	7452.84	0.16	1196.18	£ 4,000.00	£ 5,196.18	£ 1,156.32	£30,000	2010		£ 32,416.80
e9		Divert VSU	3	1.0000	1.2	1.20	50.00	4.50	1.1	0.80	1.375	0.75	1.03	0.10	1.13	6,570.00	7452.84	0.16	1196.18	£ 4,000.00	£ 5,196.18	£ 1,156.32	£29,000	2010		£ 31,336.24
e10		Indexing	3.6	0.5000	1.2	2.40	25.00	5.40	0.55	0.80	0.6875	0.75	0.52	0.10	0.57	6,570.00	3726.42	0.16	598.09	£ 1,500.00	£ 2,098.09	£ 578.16	£9,000	2010		£ 9,725.04
e11		Sortation induct	3.6	1.2000	1.2	1.00	60.00	5.40	0.75	0.80	0.9375	0.75	0.70	0.10	0.77	6,570.00	5081.48	0.16	815.58	£ 3,000.00	£ 3,815.58	£ 788.40	£36,000	2010		£ 38,900.16
e12		Sortation loop (10m per lateral pitch needed)	10	1.2000	1.2	1.00	60.00	15.00	0.75	0.80	0.9375	0.75	0.70	0.10	0.77	6,570.00	5081.48	0.16	815.58		£ 815.58	£ 788.40	£6,000	2010		£ 6,483.36
e21		Power bus (1 off assembly) unit)	1	n/a	n/a	n/a	n/a	0.00	0	0.80	0	0.75	0.00	0.10	0.00	6,570.00	0.00	0.16	500.00	£ 500.00	£ 1,000.00	£ -	£1,332,000	2010		£ 1,439,305.92
e22		Scanner array (1 unit)	2.4	1.0000	1.2	1.20	50.00	4.20	0.1	0.80	0.125	0.75	0.09	0.10	0.10	6,570.00	677.53	0.16	108.74	£ 3,000.00	£ 3,108.74	£ 105.12	£37,000	2010		£ 39,980.72
f2		ULD Powered Rollerbed (1x2m rollerbed)	2	0.5000	3	6.00	10.00	16.00	3	0.80	3.75	0.75	2.81	0.10	3.09	6,570.00	20325.94	0.16	3262.31	£ 2,000.00	£ 5,262.31	£ 3,153.60	£20,000	2011		£ 20,000.00
g1	Automatic ULD Build	Robotics (Grenzebach)	6	4bags/min	n/a	n/a	4.00	30.00	1.1	0.80	1.375	0.75	1.03	0.10	1.13	6,570.00	7452.84	0.16	1196.18	£ 3,000.00	£ 4,196.18	£ 1,156.32	£392,000	2011		£ 392,000.00
g2		Manipulator (RTT type unit)	6	6bags/min	n/a	n/a	6.00	36.00	1.1	0.80	1.375	0.75	1.03	0.10	1.13	6,570.00	7452.84	0.16	1196.18	£ 3,000.00	£ 4,196.18	£ 1,156.32	£58,000	2011		£ 58,000.00
h1	Power	Power Conditioner (1 off per facility)	2	n/a	n/a	n/a	n/a	2.00	0.15	0.80	0.1875	0.75	0.14	0.10	0.15	6,570.00	1016.30	0.16	163.12	£ 500.00	£ 663.12	£ 157.68	£5,000	2011		£ 5,000.00
h2		Power Incomer (1 off per drive)	0.05	n/a	n/a	n/a	n/a	0.05	0	0.80	0	0.75	0.00	0.10	0.00	6,570.00	0.00	0.16	0.00	£ 500.00	£ 500.00	£ -	£1,000	2010		£ 1,080.56
h3		Motor Controllers (1 off)	5	n/a	n/a	n/a	n/a	5.00	0.15	0.80	0.1875	0.75	0.14	0.10	0.15	6,570.00	1016.30	0.16	163.12	£ 1,000.00	£ 1,163.12	£ 157.68	£15,000	2011		£ 15,000.00
h4	IT	Programmable Controller Computer (1 off)	1	n/a	n/a	n/a	n/a	1.00	0.25	0.80	0.3125	0.75	0.23	0.10	0.26	6,570.00	1693.83	0.16	271.86	£ 5,000.00	£ 5,271.86	£ 262.80	£10,000	2011		£ 10,000.00
h5		Programmable Controller Module (1 off)	0.05	n/a	n/a	n/a	n/a	0.05	0.25	0.80	0.3125	0.75	0.23	0.10	0.26	6,570.00	1693.83	0.16	271.86	£ 1,000.00	£ 1,271.86	£ 262.80	£2,000	2010		£ 2,161.12
h6		Programmable Controller Software (1 off system cost)	0	n/a	n/a	n/a	n/a	0.00	0.25	0.80	0.3125	0.75	0.23	0.10	0.26	6,570.00	1693.83	0.16	271.86	£ 1,000.00	£ 1,271.86	£ 262.80	£10,000	2011		£ 10,000.00
h7		Sort Allocation Computer (1 off Unit and software)	2	n/a	n/a	n/a	n/a	2.00	0.25	0.80	0.3125	0.75	0.23	0.10	0.26	6,570.00	1693.83	0.16	271.86	£ 5,000.00	£ 5,271.86	£ 262.80	£447,000	2010		£ 483,010.32
h8		Control System Computer and Display (1 off)	1	n/a	n/a	n/a	n/a	1.00	0.25	0.80	0.3125	0.75	0.23	0.10	0.26	6,570.00	1693.83	0.16	271.86	£ 10,000.00	£ 10,271.86	£ 262.80	£15,000	2011		£ 15,000.00
h9		Safety Equipment (per drive)	0.05	n/a	n/a	n/a	n/a	0.05	0.01	0.80	0.0125	0.75	0.01	0.10	0.01	6,570.00	67.75	0.16	10.87	£ 500.00	£ 510.87	£ 10.51	£1,000	2010		£ 1,080.56
h10		Network (per drive)	0	n/a	n/a	n/a	n/a	0.00	0.01	0.80	0.0125	0.75	0.01	0.10	0.01	6,570.00	67.75	0.16	10.87	£ 600.00	£ 610.87	£ 10.51	£100,000	2010		£ 108,056.00
h11		SCADA system (base hardware / software)	2	n/a	n/a	n/a	n/a	2.00	0.25	0.80	0.3125	0.75	0.23	0.10	0.26	6,570.00	1693.83	0.16	271.86	£ 10,000.00	£ 10,271.86	£ 262.80	£122,000	2010		£ 131,828.32
i1	Handling Agent	Manual loader (lateral racetrack chute)	1	2bags/min/oper	n/a	n/a	2.00	1.50	N/A	0.80		0.00	0.00	0.00	0.00	6,570.00	0.00	0.16	0.00	£ -	£ -	£ 30,849.99	£0	2010		£ -
i2		Manual loader (Robotics support & top up)	1	2bags/min/oper	n/a	n/a	2.00	1.50	N/A	0.80		0.00	0.00	0.00	0.00	6,570.00	0.00	0.16	0.00	£ -	£ -	£ 30,849.99	£0	2010		£ -
i3		Manual loader (RTT)	1	6bags/min/oper	n/a	n/a	6.00	1.50	N/A	0.80		0.00	0.00	0.00	0.00	6,570.00	0.00	0.16	0.00	£ -	£ -	£ 30,849.99	£0	2010		£ -
j1	Steelwork	Platform (per m run)	1	n/a	n/a	n/a	n/a	0.00	N/A	0.80		0.75	0.00	0.10	0.00	6,570.00	0.00	0.16	0.00	£ -	£ 10.00	N/A	£1,000	2010		£ 1,080.56
j3		Stairs (per ladder)	1	n/a	n/a	n/a	n/a	0.00	N/A	0.80		0.75	0.00	0.10	0.00	6,570.00	0.00	0.16	0.00	£ -	£ 15.00	N/A	£2,000	2010		£ 2,161.12
k1	Sub equipment	Fire door (per door)	1	n/a	n/a	n/a	n/a	2.00	N/A			0.75	0.00	0.10	0.00	6,570.00	0.00	0.16	0.00	£ -	£ 1,000.00	N/A	£13,000	2010		£ 14,047.28

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APPENDIX D ASSEMBLY ENVIRONMENT WORKSHEET – SELECTED EQUIPMENT CONFIGURATIONS

Process Step	Fully Auto Build	Semi Auto Build	Manual Build
	% included	% included	% included
Check-in	100%	100%	100%
Delivery	100%	100%	100%
EBS (% of bags/hr pre-stored)	38%	38%	38%
HBS	100%	100%	100%
Flight Sortation (LATERAL OR RACETRACK)	75%	75%	100%
ULD Distribution (POWERED ROLLERBED)	100%	100%	100%
Automatic ULD Build	25%	25%	0%
Power	100%	100%	100%
IT	100%	100%	100%

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APPENDIX E ASSEMBLY ENVIRONMENT WORKSHEET – SAMPLE DATA PROVIDED

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
	Demand	5940	Bags/Hour				Fully Automatic				Semi Automatic				Manual			
		99	Bags/Min	Fully	Semi	Manual	Baggage	Baggage	Building	Building	Baggage	Baggage	Building	Building	Baggage	Baggage	Building	Building
Ref ID	System Function	Sub System Technology	Process Qty	Actual Qty	Actual Qty	Actual Qty	CAPEX	OPEX	CAPEX	OPEX	CAPEX	OPEX	CAPEX	OPEX	CAPEX	OPEX	CAPEX	OPEX
a1	Check-in	Conventional Conveyor (3x1.2m assembly)	148	£148	£148	£148	£1,992,019	£804,816	£2,378,741	£52,662	£1,992,019	£804,816	£2,378,741	£52,662	£1,992,019	£804,816	£2,378,741	£52,662
b1	Delivery	Collector Belt (1x20m)	4	4	4	4	£27,233	£27,471	£354,168	£7,841	£27,233	£27,471	£354,168	£7,841	£27,233	£27,471	£354,168	£7,841
b4		Powered Belt Curve	4	40	40	40	£1,259,289	£143,794	£579,506	£12,829	£1,259,289	£143,794	£579,506	£12,829	£1,259,289	£143,794	£579,506	£12,829
c1	Early Baggage Store	Conveyor Lane Q conveyors (1x1.2m)	2	2,257	2,257	2,257	£6,771,600	£6,085,821	£12,112,548	£268,155	£6,771,600	£6,085,821	£12,112,548	£268,155	£6,771,600	£6,085,821	£12,112,548	£268,155
d1	Hold Baggage Screening	Standard 2 Level 1 Unit	5	5	5	5	£1,237,500	£144,321	£368,925	£8,168	£1,237,500	£144,321	£368,925	£8,168	£1,237,500	£144,321	£368,925	£8,168
d2		Standard 2 Level 3 Unit 5% reject rate	1	1	1	1	£928,125	£36,080	£124,512	£2,757	£928,125	£36,080	£124,512	£2,757	£928,125	£36,080	£124,512	£2,757
d3		Standard 2 Level 2 Workstation 20% reject rat	7	7	7	7	£99,000	£1,378	£19,676	£436	£99,000	£1,378	£19,676	£436	£99,000	£1,378	£19,676	£436
e1	Flight Sortation	Flight Lateral (1x28m)	10	14	14	0	£201,067	£110,391	£8,451,738	£187,110	£201,067	£110,391	£8,451,738	£187,110	£0	£0	£0	£0
e3		Flight Racetracks (1x40m length unit)	10	Not used	Not used	10	£0	£0	£0	£0	£0	£0	£0	£0	£217,525	£73,184	£14,875,059	£329,314
e9		Divert VSU	2	12	10	16	£379,090	£62,861	£162,293	£3,593	£314,459	£52,144	£134,624	£2,980	£495,426	£82,152	£212,098	£4,696
e10		Indexing	4	75	65	94	£734,119	£158,380	£1,215,239	£26,904	£633,829	£136,743	£1,049,223	£23,228	£914,640	£197,325	£1,514,069	£33,519
e11		Sortation induct	2	2	2	0	£64,185	£6,296	£26,563	£588	£64,185	£6,296	£26,563	£588	£0	£0	£0	£0
e12		Sortation loop (10m per lateral pitch needed)	2	39	35	0	£255,282	£32,113	£1,760,779	£3,898	£228,538	£28,749	£1,576,316	£3,490	£0	£0	£0	£0
e21		Power bus (1 off assembly) unit)	1	1	1	1	£1,439,306	£1,000	£0	£0	£1,439,306	£1,000	£0	£0	£1,439,306	£1,000	£0	£0
e22		Scanner array (1 unit)	2	2	2	2	£65,968	£5,129	£20,660	£457	£65,968	£5,129	£20,660	£457	£65,968	£5,129	£20,660	£457
f2		ULD Powered Rollerbed	10	117	108	90	£2,336,250	£614,704	£5,571,887	£123,354	£2,157,500	£567,672	£5,145,573	£113,916	£1,800,000	£473,608	£4,292,946	£95,040
g1	Automatic ULD Build	Robotics (Grenzebach)	25	6	0	0	£2,425,500	£25,964	£553,388	£12,251	£0	£0	£0	£0	£0	£0	£0	£0
g2		Manipulator (RTT type unit)	17	0	4	0	£0	£0	£0	£0	£239,250	£17,309	£442,710	£9,801	£0	£0	£0	£0
h1	Power	Power Conditioner (1 off per facility)	1	1	1	1	£5,000	£663	£5,962	£132	£5,000	£663	£5,962	£132	£5,000	£663	£5,962	£132
h2		Power Incomer (1 off per drive)	1	1	1	1	£1,081	£500	£149	£3	£1,081	£500	£149	£3	£1,081	£500	£149	£3
h3		Motor Controllers (1 off)	1	1	1	1	£15,000	£1,163	£14,906	£330	£15,000	£1,163	£14,906	£330	£15,000	£1,163	£14,906	£330
h4	IT	Programmable Controller Computer (1 off)	1	1	1	1	£10,000	£5,272	£2,981	£66	£10,000	£5,272	£2,981	£66	£10,000	£5,272	£2,981	£66
h5		Programmable Controller Module	1	2,681	2,660	2,671	£5,793,652	£3,409,672	£399,610	£8,847	£5,747,593	£3,382,566	£396,433	£8,776	£5,772,500	£3,397,224	£398,151	£8,815
h6		Programmable Controller Software (1 off syste	1	1	1	1	£10,000	£1,272	£0	£0	£10,000	£1,272	£0	£0	£10,000	£1,272	£0	£0
h7		Sort Allocation Computer (1 off Unit and softw	1	1	1	1	£483,010	£5,272	£5,962	£132	£483,010	£5,272	£5,962	£132	£483,010	£5,272	£5,962	£132
h8		Control System Computer and Display (1 off)	10	10	10	10	£150,000	£102,719	£29,812	£660	£150,000	£102,719	£29,812	£660	£150,000	£102,719	£29,812	£660
h9		Safety Equipment (per drive)	1	2,681	2,660	2,671	£2,896,826	£1,369,581	£399,610	£8,847	£2,873,797	£1,358,693	£396,433	£8,776	£2,886,250	£1,364,581	£398,151	£8,815
h10		Network (per installation)	1	1	1	1	£108,056	£1,637,666	£0	£0	£108,056	£1,624,647	£0	£0	£108,056	£1,631,687	£0	£0
h11		SCADA system (base hardware / software)	1	1	1	1	£131,828	£10,272	£5,962	£132	£131,828	£10,272	£5,962	£132	£131,828	£10,272	£5,962	£132
i1	Handling Agent	Manual loader (lateral racetrack chute)	50	37	37	50	£0	£4,008,570	£166,016	£3,675	£0	£4,008,570	£166,016	£3,675	£0	£5,344,760	£221,355	£4,901
i2		Manual loader (Robotics support & top up)	50	6	0	0	£0	£668,095	£27,669	£613	£0	£0	£0	£0	£0	£0	£0	£0
i3		Manual loader (RTT)	17	Not used	4	Not used	£0	£0	£0	£0	£0	£445,397	£18,446	£408	£0	£0	£0	£0
j1	Steel work	Platform (per m run)	N/A	3,820	3,777	3,647	£4,127,658	£38,199	£0	£0	£4,081,228	£37,770	£0	£0	£3,941,006	£36,472	£0	£0
j3		Stairs (per ladder)	N/A	89	89	89	£193,122	£1,340	£0	£0	£191,586	£1,330	£0	£0	£192,417	£1,336	£0	£0
k1	Sub equipment	Fire door (per door)	4	4	4	4	£55,627	£3,960	£23,611	£523	£55,627	£3,960	£23,611	£523	£55,627	£3,960	£23,611	£523
							£20,175,873	£21,477,208	£20,521,897	£808,459	£18,598,379	£21,075,096	£19,972,774	£789,836	£18,295,550	£21,981,555	£22,396,349	£924,419
						Calculated "On-Cost"	£9,483,442				£8,741,959				£8,599,618			
						Calculated Total CAPEX + On cost	£50,181,212				£47,313,112				£49,291,516			

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APPENDIX F PEAKING FACTOR WORKSHEET

Cat A	<999 BAGS/HR
Cat B	>1000<4999 BAGS/HR
Cat C	>5000 BAGS/HR

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of Flights		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Long haul Bags/Hr		400	800	1200	1600	2000	2400	2800	3200	3600	4000	4400	4800	5200	5600	6000
Short haul Bags/hr		180	360	540	720	900	1080	1260	1440	1620	1800	1980	2160	2340	2520	2700
1:1 Long/Short haul Bags/hr		580	1160	1740	2320	2900	3480	4060	4640	5220	5800	6380	6960	7540	8120	8700
Time (Minutes)		0	5	10	15	20	25	30	35	40	45	50	55	60	65	70
Single flight % non cumulative bags in BHS		0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%
H	I	J														
Flights per hour	Peaking Factor	% Non Cummulative quantity of bags entering BHS / flight														
2 flights/Hour (offset then is 30minutes)		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%
				30 Minutes between flights												
Total	7.09%	0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.77%	1.07%	1.42%	1.82%	2.28%	2.77%	3.29%
8-12-28 flights/hour (offset then is 5-10 minutes)			0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%
				0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%
			5 Minutes between flights		0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%
						0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%
							0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%
								0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%
									0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%
										0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%
											0.00%	0.00%	0.01%	0.04%	0.10%	0.20%
												0.00%	0.00%	0.01%	0.04%	0.10%
													0.00%	0.00%	0.01%	0.04%
														0.00%	0.00%	0.01%
Total	45.14%	0.00%	0.00%	0.01%	0.05%	0.15%	0.35%	0.69%	1.22%	1.98%	3.01%	4.33%	5.95%	7.89%	10.13%	12.66%
5 flights (offset 10-12 minutes)				0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%
						0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%
				10 Minutes between flights				0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%	0.53%	0.76%
										0.00%	0.00%	0.01%	0.04%	0.10%	0.20%	0.34%
												0.00%	0.00%	0.01%	0.04%	0.10%
Total	21.03%	0.00%	0.00%	0.01%	0.04%	0.11%	0.24%	0.45%	0.77%	1.21%	1.80%	2.53%	3.42%	4.47%	5.66%	6.99%

		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Number of Flights		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Long haul Bags/Hr		6400	6800	7200	7600	8000	8400	8800	9200	9600	10000	10400	10800	11200	11600	12000
Short haul Bags/hr		2880	3060	3240	3420	3600	3780	3960	4140	4320	4500	4680	4860	5040	5220	5400
1:1 Long/Short haul Bags/hr		9280	9860	10440	11020	11600	12180	12760	13340	13920	14500	15080	15660	16240	16820	17400
Time (Minutes)		75	80	85	90	95	100	105	110	115	120	125	130	135	140	145
Single flight % non cumulative bags in BHS		2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%	3.63%	3.56%	3.46%	3.35%	3.22%	3.08%
2 flights/Hour (offset then is 30minutes)		1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%
Total	7.09%	3.83%	4.35%	4.86%	5.34%	5.77%	6.15%	6.47%	6.73%	6.91%	7.03%	7.09%	7.09%	7.02%	6.91%	6.76%
8-12-28 flights/hour (offset then is 5-10 minutes)		2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%	3.63%	3.56%	3.46%	3.35%	3.22%
		2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%	3.63%	3.56%	3.46%	3.35%
		1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%	3.63%	3.56%	3.46%
		1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%	3.63%	3.56%
		1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%	3.63%
		1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%
		0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%
		0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%
		0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%
		0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%
		0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%
		0.04%	0.10%	0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%
Total	45.14%	15.45%	18.44%	21.58%	24.79%	27.98%	31.07%	33.98%	36.65%	39.00%	41.01%	42.63%	43.85%	44.67%	45.09%	45.14%
5 flights (offset 10-12 minutes)		2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%	3.63%	3.56%	3.46%	3.35%
		1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%	3.63%	3.56%
		1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%	3.69%	3.68%
		0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%	3.62%	3.67%
		0.20%	0.34%	0.53%	0.76%	1.03%	1.32%	1.63%	1.94%	2.24%	2.53%	2.80%	3.03%	3.24%	3.40%	3.53%
Total	21.03%	8.42%	9.92%	11.46%	12.99%	14.46%	15.85%	17.11%	18.22%	19.16%	19.91%	20.47%	20.84%	21.03%	21.03%	20.87%

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APPENDIX G RESULTS - STAFF DATA BASE WORKSHEET / COMPLETED QUESTIONNAIRE

ITEM	QUESTION ASKED	UNITS	IATA	US CARRIER	CANADIAN CARRIER	AIRPORT OPERATING COMMITTEE	AIRPORT OPERATOR FINANCE	MEAN	Mode	MEDIAN	ACTUL DATA TO USE Q4 2011
1	What are the qualifications of a typical baggage loader?	Grades	3 C grades 0 Level	3 C grades 0 Level	3 C grades 0 Level	3 C grades 0 Level	3 C grades 0 Level	3 C grades 0 Level	3 C grades 0 Level	3 C grades 0 Level	3 C grades 0 Level
2	Generally what are the career aspirations of typical baggage handler?	Grades	Aspire to Team Leader	Do currnet job for ever	Do currnet job for ever	Aspire to Team Leader	Do currnet job for ever	Aspire to Team Leader	Aspire to Team Leader	Aspire to Team Leader	Aspire to Team Leader
3	What is the salary scale of a typical baggage handler on average?	£/Pa	30000	18250	19999	30000	30000	25650	30000	30000	28550
4	What is the peak bag processing rate of a baggage loader (Peak 5 minute rate)	Bags/min	4	3	5	4	3	4	4	4	4
5	What is the average bag processing rate of a baggage loader (Sustainable rate)	Bags/min	2	2	2	3	2	2	2	2	2
6	How many baggage handling operatives (drivers /loaders) would be used process 1million bags per annum (Manual “racetrack” baggage	Staff / 1mppa Manual	75	70	50	50	75	64	75	70	70
7	How many baggage handling operatives (drivers /loaders would be used process 1million bags per annum (Automatic “chute/lateral” baggage	Staff / 1mppa Automatic	45	90	50	50	50	57	50	50	52

Interview results sourced from:

Cowper A, (2010), UK Airport,

Dolye H, (2010), American Airlines,

Stewart D, (2010), International Air Transport Association (IATA)

Shortland (2010), Airport Operational Committee Heathrow Airport

Taylor, (2010), Air Canada

X. APPENDICES

APPENDIX H RESULTS WORKSHEET

			Graphed Results		Sensitivities														
		Test	Pax/Hour	Bags/Hour	# of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflation Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min
BASE	Short Haul Only	1	180	180	1	0	0%		0.59			0.59			3			2	
		2	360	360	2	0	0%		0.59			0.59			3			2	
		3	540	540	3	0	0%		0.59			0.59			3			2	
		4	720	720	4	0	0%		0.59			0.59			3			2	
		5	900	900	5	0	0%		0.59			0.59			3			2	
		6	1080	1080	6	0	0%		0.59			0.59			3			2	
		7	1260	1260	7	0	0%		0.59			0.59			3			2	
		8	1440	1440	8	0	0%		0.59			0.59			3			2	
		9	1620	1620	9	0	0%		0.59			0.59			3			2	
		10	1800	1800	10	0	0%		0.59			0.59			3			2	
		11	1980	1980	11	0	0%		0.59			0.59			3			2	
		12	2160	2160	12	0	0%		0.59			0.59			3			2	
		13	2340	2340	13	0	0%		0.59			0.59			3			2	
		14	2520	2520	14	0	0%		0.59			0.59			3			2	
		15	2700	2700	15	0	0%		0.59			0.59			3			2	
		16	2880	2880	16	0	0%		0.59			0.59			3			2	
		17	3060	3060	17	0	0%		0.59			0.59			3			2	
		18	3240	3240	18	0	0%		0.59			0.59			3			2	
		19	3420	3420	19	0	0%		0.59			0.59			3			2	
		20	3600	3600	20	0	0%		0.59			0.59			3			2	
		21	3780	3780	21	0	0%		0.59			0.59			3			2	
		22	3960	3960	22	0	0%		0.59			0.59			3			2	
		23	4140	4140	23	0	0%		0.59			0.59			3			2	
		24	4320	4320	24	0	0%		0.59			0.59			3			2	
		25	4500	4500	25	0	0%		0.59			0.59			3			2	
		26	4680	4680	26	0	0%		0.59			0.59			3			2	
		27	4860	4860	27	0	0%		0.59			0.59			3			2	
		28	5040	5040	28	0	0%		0.59			0.59			3			2	
		29	5220	5220	29	0	0%		0.59			0.59			3			2	
		30	5400	5400	30	0	0%		0.59			0.59			3			2	
	Long Haul Only	31	400	480	0	1	0%		0.59			0.59			3			2	
		32	800	960	0	2	0%		0.59			0.59			3			2	
		33	1200	1440	0	3	0%		0.59			0.59			3			2	
		34	1600	1920	0	4	0%		0.59			0.59			3			2	
		35	2000	2400	0	5	0%		0.59			0.59			3			2	
		36	2400	2880	0	6	0%		0.59			0.59			3			2	
		37	2800	3360	0	7	0%		0.59			0.59			3			2	
		38	3200	3840	0	8	0%		0.59			0.59			3			2	
		39	3600	4320	0	9	0%		0.59			0.59			3			2	
		40	4000	4800	0	10	0%		0.59			0.59			3			2	
		41	4400	5280	0	11	0%		0.59			0.59			3			2	
		42	4800	5760	0	12	0%		0.59			0.59			3			2	
		43	5200	6240	0	13	0%		0.59			0.59			3			2	
		44	5600	6720	0	14	0%		0.59			0.59			3			2	
		45	6000	7200	0	15	0%		0.59			0.59			3			2	
	Short Haul and Long Haul Mix	46	580	660	1	1	0%		0.59			0.59			3			2	
		47	1160	1320	2	2	0%		0.59			0.59			3			2	
		48	1740	1980	3	3	0%		0.59			0.59			3			2	
		49	2320	2640	4	4	0%		0.59			0.59			3			2	
		50	2900	3300	5	5	0%		0.59			0.59			3			2	
		51	3480	3960	6	6	0%		0.59			0.59			3			2	
		52	4060	4620	7	7	0%		0.59			0.59			3			2	
		53	4640	5280	8	8	0%		0.59			0.59			3			2	
		54	5220	5940	9	9	0%		0.59			0.59			3			2	
		55	5800	6600	10	10	0%		0.59			0.59			3			2	
		56	6380	7260	11	11	0%		0.59			0.59			3			2	
		57	6960	7920	12	12	0%		0.59			0.59			3			2	
		58	7540	8580	13	13	0%		0.59			0.59			3			2	
		59	8120	9240	14	14	0%		0.59			0.59			3			2	
		60	8700	9900	15	15	0%		0.59			0.59			3			2	

	Fully Automated						Semi Automated					
Test	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²
1	1,971,621	817,652	926,738	425,999	17,116	259	1,925,196	801,518	904,917	419,744	16,825	255
2	2,554,807	1,596,521	1,200,858	776,399	33,373	506	2,461,956	1,564,252	1,157,215	763,890	32,790	497
3	3,137,993	2,375,389	1,474,978	1,126,800	49,631	752	2,998,716	2,326,986	1,409,513	1,108,035	48,756	739
4	3,721,178	3,154,257	1,749,098	1,477,201	65,888	998	3,535,476	3,089,720	1,661,811	1,452,181	64,722	981
5	4,304,364	3,933,125	2,023,218	1,827,601	82,146	1,245	4,072,236	3,852,454	1,914,109	1,796,327	80,688	1,223
6	4,887,549	4,711,994	2,297,338	2,178,002	98,403	1,491	4,608,996	4,615,187	2,166,407	2,140,473	96,654	1,464
7	5,470,735	5,490,862	2,571,457	2,528,403	114,661	1,737	5,145,756	5,377,921	2,418,705	2,484,618	112,620	1,706
8	6,053,920	6,269,730	2,845,577	2,878,803	130,918	1,984	5,682,516	6,140,655	2,671,003	2,828,764	128,586	1,948
9	6,637,106	7,048,599	3,119,697	3,229,204	147,175	2,230	6,219,276	6,903,389	2,923,301	3,172,910	144,552	2,190
10	7,220,291	7,827,467	3,393,817	3,579,605	163,433	2,476	6,756,036	7,666,123	3,175,599	3,517,056	160,518	2,432
11	7,826,892	8,614,932	3,678,942	3,934,779	179,881	2,725	7,292,796	8,428,857	3,427,897	3,861,202	176,484	2,674
12	8,414,209	9,395,317	3,955,004	4,286,022	196,172	2,972	7,829,556	9,191,591	3,680,195	4,205,347	192,450	2,916
13	9,001,527	10,175,703	4,231,066	4,637,265	212,463	3,219	8,366,316	9,954,325	3,932,493	4,549,493	208,416	3,158
14	9,613,085	10,964,988	4,518,523	4,993,451	228,951	3,469	8,927,317	10,725,959	4,196,185	4,898,581	224,579	3,403
15	10,203,708	11,746,587	4,796,138	5,345,368	245,268	3,716	9,467,383	11,489,906	4,450,037	5,243,401	240,572	3,645
16	10,794,332	12,528,186	5,073,754	5,697,285	261,586	3,963	10,029,486	12,261,945	4,714,247	5,592,714	256,743	3,890
17	11,407,873	13,318,200	5,362,143	6,053,875	278,090	4,213	10,595,225	13,035,318	4,980,167	5,942,768	272,945	4,136
18	12,001,141	14,100,770	5,641,002	6,406,331	294,430	4,461	11,140,690	13,801,248	5,236,556	6,288,688	288,982	4,379
19	12,594,409	14,883,339	5,919,860	6,758,787	310,769	4,709	11,686,155	14,567,178	5,492,946	6,634,609	305,018	4,621
20	13,187,676	15,665,909	6,198,719	7,111,244	327,109	4,956	12,231,619	15,333,108	5,749,335	6,980,529	321,055	4,864
21	13,780,944	16,448,479	6,477,578	7,463,700	343,448	5,204	12,777,084	16,099,038	6,005,725	7,326,450	337,092	5,107
22	14,374,212	17,231,049	6,756,437	7,816,156	359,787	5,451	13,322,549	16,864,968	6,262,115	7,672,370	353,128	5,350
23	14,967,479	18,013,619	7,035,295	8,168,612	376,127	5,699	13,868,014	17,630,897	6,518,504	8,018,291	369,165	5,593
24	15,560,747	18,796,189	7,314,154	8,521,068	392,466	5,946	14,413,479	18,396,827	6,774,894	8,364,211	385,202	5,836
25	16,154,014	19,578,759	7,593,013	8,873,525	408,805	6,194	14,958,943	19,162,757	7,031,283	8,710,132	401,238	6,079
26	16,747,282	20,361,329	7,871,872	9,225,981	425,145	6,442	15,504,408	19,928,687	7,287,673	9,056,052	417,275	6,322
27	17,340,550	21,143,899	8,150,731	9,578,437	441,484	6,689	16,049,873	20,694,617	7,544,062	9,401,973	433,312	6,565
28	17,933,817	21,926,469	8,429,589	9,930,893	457,823	6,937	16,595,338	21,460,547	7,800,452	9,747,893	449,349	6,808
29	18,527,085	22,709,039	8,708,448	10,283,350	474,163	7,184	17,140,802	22,226,476	8,056,842	10,093,814	465,385	7,051
30	19,120,352	23,491,609	8,987,307	10,635,806	490,502	7,432	17,686,267	22,992,406	8,313,231	10,439,734	481,422	7,294
31	2,863,121	1,524,942	1,345,778	990,713	32,446	492	2,739,320	1,481,917	1,287,587	974,033	31,669	480
32	4,337,807	3,011,099	2,038,937	1,905,828	64,033	970	4,090,204	2,925,049	1,922,555	1,872,469	62,479	947
33	5,812,493	4,497,256	2,732,097	2,820,943	95,620	1,449	5,441,089	4,368,181	2,557,523	2,770,904	93,289	1,413
34	7,309,216	5,991,505	3,435,615	3,740,551	127,387	1,930	6,791,973	5,811,314	3,192,491	3,669,339	124,099	1,880
35	8,816,957	7,489,799	4,144,312	4,662,406	159,243	2,413	8,164,894	7,262,537	3,837,817	4,572,267	155,088	2,350
36	10,311,476	8,983,238	4,846,794	5,581,564	190,991	2,894	9,546,631	8,716,997	4,487,287	5,476,993	186,149	2,820
37	11,833,322	10,486,711	5,562,120	6,506,295	222,962	3,378	10,941,002	10,176,096	5,142,695	6,384,295	217,312	3,293
38	13,334,893	11,982,739	6,267,917	7,426,891	254,768	3,860	12,315,099	11,627,751	5,788,574	7,287,462	248,311	3,762
39	14,836,464	13,478,768	6,973,713	8,347,488	286,574	4,342	13,689,196	13,079,406	6,434,453	8,190,630	279,309	4,232
40	16,338,035	14,974,796	7,679,510	9,268,084	318,379	4,824	15,063,293	14,531,061	7,080,332	9,093,798	310,308	4,702
41	17,839,606	16,470,825	8,385,307	10,188,681	350,185	5,306	16,437,390	15,982,716	7,726,210	9,996,966	341,307	5,171
42	19,341,177	17,966,853	9,091,103	11,109,277	381,991	5,788	17,811,486	17,434,371	8,372,089	10,900,134	372,305	5,641
43	20,842,749	19,462,881	9,796,900	12,029,874	413,797	6,270	19,185,583	18,886,026	9,017,968	11,803,302	403,304	6,111
44	22,344,320	20,958,910	10,502,696	12,950,470	445,603	6,752	20,559,680	20,337,681	9,663,847	12,706,470	434,303	6,580
45	23,845,891	22,454,938	11,208,493	13,871,067	477,408	7,233	21,933,777	21,789,336	10,309,726	13,609,638	465,301	7,050
46	3,446,307	2,303,810	1,619,898	1,341,114	48,703	738	3,276,080	2,244,650	1,539,885	1,318,179	47,635	722
47	5,504,178	4,568,836	2,587,177	2,606,629	96,548	1,463	5,163,724	4,450,517	2,427,151	2,560,760	94,410	1,430
48	7,585,464	6,842,458	3,565,462	3,876,919	144,583	2,191	7,051,369	6,656,383	3,314,417	3,803,341	141,186	2,139
49	9,684,931	9,122,756	4,552,293	5,150,915	192,766	2,921	8,965,458	8,871,959	4,214,113	5,051,314	188,177	2,851
50	11,796,518	11,407,503	5,544,821	6,427,383	241,047	3,652	10,920,132	11,102,435	5,132,885	6,307,561	235,498	3,568
51	13,891,356	13,686,102	6,529,476	7,700,435	289,192	4,382	12,839,694	13,320,020	6,035,154	7,556,650	282,533	4,281
52	15,986,195	15,964,700	7,514,131	8,973,488	337,338	5,111	14,759,256	15,537,605	6,937,422	8,805,738	329,569	4,993
53	18,081,034	18,243,298	8,498,787	10,246,541	385,483	5,841	16,678,817	17,755,190	7,839,691	10,054,827	376,604	5,706
54	20,175,873	20,521,897	9,483,442	11,519,594	433,628	6,570	18,598,379	19,972,774	8,741,959	11,303,915	423,640	6,419
55	22,270,711	22,800,495	10,468,098	12,792,646	481,773	7,300	20,517,940	22,190,359	9,644,227	12,553,003	470,675	7,131
56	24,365,550	25,079,094	11,452,753	14,065,699	529,918	8,029	22,437,502	24,407,944	10,546,496	13,802,092	517,710	7,844
57	26,460,389	27,357,692	12,437,408	15,338,752	578,063	8,759	24,357,064	26,625,529	11,448,764	15,051,180	564,746	8,557
58	28,555,228	29,636,290	13,422,064	16,611,805	626,209	9,488	26,276,625	28,843,114	12,351,033	16,300,269	611,781	9,269
59	30,650,066	31,914,889	14,406,719	17,884,857	674,354	10,217	28,196,187	31,060,698	13,253,301	17,549,357	658,816	9,982
60	32,744,905	34,193,487	15,391,375	19,157,910	722,499	10,947	30,115,749	33,278,283	14,155,569	18,798,446	705,852	10,695

	Manual						Result and Ranking					
							Graphed Results			Ranking Results		
Test	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
1	1,898,551	729,572	892,393	431,168	16,152	245	(£ 4,411,881.)	(£ 4,266,482.)	(£ 4,273,810.)	3rd Most expensive	1st Cheapest	2nd Cheapest
2	2,408,667	1,420,361	1,132,167	786,739	31,445	476	(£ 6,111,178.)	(£ 5,820,381.)	(£ 5,835,037.)	3rd Most expensive	1st Cheapest	2nd Cheapest
3	2,918,782	2,111,149	1,371,941	1,142,309	46,738	708	(£ 7,810,476.)	(£ 7,374,280.)	(£ 7,396,264.)	3rd Most expensive	1st Cheapest	2nd Cheapest
4	3,428,897	2,801,938	1,611,715	1,497,879	62,031	940	(£ 9,509,774.)	(£ 8,928,179.)	(£ 8,957,491.)	3rd Most expensive	1st Cheapest	2nd Cheapest
5	3,939,013	3,492,726	1,851,489	1,853,450	77,324	1,172	(£ 11,209,072.)	(£ 10,482,078.)	(£ 10,518,718.)	3rd Most expensive	1st Cheapest	2nd Cheapest
6	4,449,128	4,183,514	2,091,263	2,209,020	92,617	1,403	(£ 12,908,369.)	(£ 12,035,977.)	(£ 12,079,945.)	3rd Most expensive	1st Cheapest	2nd Cheapest
7	4,983,484	4,883,203	2,342,431	2,569,532	108,107	1,638	(£ 14,607,667.)	(£ 13,589,876.)	(£ 13,735,195.)	3rd Most expensive	1st Cheapest	2nd Cheapest
8	5,500,211	5,576,419	2,585,312	2,926,451	123,454	1,871	(£ 16,306,965.)	(£ 15,143,775.)	(£ 15,322,064.)	3rd Most expensive	1st Cheapest	2nd Cheapest
9	6,016,937	6,269,634	2,828,194	3,283,369	138,801	2,103	(£ 18,006,263.)	(£ 16,697,674.)	(£ 16,908,934.)	3rd Most expensive	1st Cheapest	2nd Cheapest
10	6,533,664	6,962,850	3,071,075	3,640,287	154,148	2,336	(£ 19,705,560.)	(£ 18,251,573.)	(£ 18,495,804.)	3rd Most expensive	1st Cheapest	2nd Cheapest
11	7,050,390	7,656,066	3,313,957	3,997,205	169,495	2,568	(£ 21,495,676.)	(£ 19,805,472.)	(£ 20,082,673.)	3rd Most expensive	1st Cheapest	2nd Cheapest
12	7,567,117	8,349,281	3,556,838	4,354,123	184,842	2,801	(£ 23,211,000.)	(£ 21,359,372.)	(£ 21,669,543.)	3rd Most expensive	1st Cheapest	2nd Cheapest
13	8,083,843	9,042,497	3,799,720	4,711,042	200,189	3,033	(£ 24,926,324.)	(£ 22,913,271.)	(£ 23,256,412.)	3rd Most expensive	1st Cheapest	2nd Cheapest
14	8,624,811	9,744,613	4,053,995	5,072,902	215,732	3,269	(£ 26,735,672.)	(£ 24,561,192.)	(£ 24,937,305.)	3rd Most expensive	1st Cheapest	2nd Cheapest
15	9,144,843	10,439,042	4,298,431	5,430,494	231,106	3,502	(£ 28,463,817.)	(£ 26,127,913.)	(£ 26,536,996.)	3rd Most expensive	1st Cheapest	2nd Cheapest
16	9,664,875	11,133,471	4,542,866	5,788,087	246,480	3,735	(£ 30,191,963.)	(£ 27,780,108.)	(£ 28,136,687.)	3rd Most expensive	1st Cheapest	2nd Cheapest
17	10,207,826	11,836,315	4,798,074	6,150,351	262,040	3,970	(£ 32,009,003.)	(£ 29,446,407.)	(£ 29,825,272.)	3rd Most expensive	1st Cheapest	2nd Cheapest
18	10,730,503	12,531,716	5,043,752	6,508,483	277,435	4,204	(£ 33,747,405.)	(£ 31,034,069.)	(£ 31,435,220.)	3rd Most expensive	1st Cheapest	2nd Cheapest
19	11,253,179	13,227,116	5,289,430	6,866,614	292,830	4,437	(£ 35,485,808.)	(£ 32,621,731.)	(£ 33,045,168.)	3rd Most expensive	1st Cheapest	2nd Cheapest
20	11,775,856	13,922,516	5,535,109	7,224,745	308,226	4,670	(£ 37,224,211.)	(£ 34,209,393.)	(£ 34,655,115.)	3rd Most expensive	1st Cheapest	2nd Cheapest
21	12,298,532	14,617,917	5,780,787	7,582,877	323,621	4,903	(£ 38,962,614.)	(£ 35,797,054.)	(£ 36,265,063.)	3rd Most expensive	1st Cheapest	2nd Cheapest
22	12,821,209	15,313,317	6,026,465	7,941,008	339,016	5,137	(£ 40,701,016.)	(£ 37,384,716.)	(£ 37,875,011.)	3rd Most expensive	1st Cheapest	2nd Cheapest
23	13,343,886	16,008,717	6,272,144	8,299,139	354,411	5,370	(£ 42,439,419.)	(£ 38,972,378.)	(£ 39,484,959.)	3rd Most expensive	1st Cheapest	2nd Cheapest
24	13,866,562	16,704,117	6,517,822	8,657,271	369,806	5,603	(£ 44,177,822.)	(£ 40,560,040.)	(£ 41,094,907.)	3rd Most expensive	1st Cheapest	2nd Cheapest
25	14,389,239	17,399,518	6,763,500	9,015,402	385,202	5,836	(£ 45,916,224.)	(£ 42,147,702.)	(£ 42,704,855.)	3rd Most expensive	1st Cheapest	2nd Cheapest
26	14,911,915	18,094,918	7,009,178	9,373,533	400,597	6,070	(£ 47,654,627.)	(£ 43,735,363.)	(£ 44,314,803.)	3rd Most expensive	1st Cheapest	2nd Cheapest
27	15,434,592	18,790,318	7,254,857	9,731,665	415,992	6,303	(£ 49,393,030.)	(£ 45,323,025.)	(£ 45,924,751.)	3rd Most expensive	1st Cheapest	2nd Cheapest
28	15,957,269	19,485,718	7,500,535	10,089,796	431,387	6,536	(£ 51,131,432.)	(£ 46,910,687.)	(£ 47,534,699.)	3rd Most expensive	1st Cheapest	2nd Cheapest
29	16,479,945	20,181,119	7,746,213	10,447,927	446,783	6,769	(£ 52,869,835.)	(£ 48,498,349.)	(£ 49,144,647.)	3rd Most expensive	1st Cheapest	2nd Cheapest
30	17,002,622	20,876,519	7,991,891	10,806,059	462,178	7,003	(£ 54,608,238.)	(£ 50,086,010.)	(£ 50,754,595.)	3rd Most expensive	1st Cheapest	2nd Cheapest
31	2,718,177	1,817,956	1,277,648	1,013,747	40,247	610	(£ 6,268,031.)	(£ 5,880,301.)	(£ 6,658,557.)	2nd Cheapest	1st Cheapest	3rd Most expensive
32	4,047,917	3,597,129	1,902,678	1,951,896	79,636	1,207	(£ 9,823,480.)	(£ 9,048,020.)	(£ 10,604,531.)	2nd Cheapest	1st Cheapest	3rd Most expensive
33	5,408,510	5,387,628	2,542,209	2,896,335	119,275	1,807	(£ 13,378,928.)	(£ 12,215,738.)	(£ 14,670,171.)	2nd Cheapest	1st Cheapest	3rd Most expensive
34	6,755,881	7,173,273	3,175,526	3,838,079	158,807	2,406	(£ 17,019,852.)	(£ 15,383,457.)	(£ 18,684,525.)	2nd Cheapest	1st Cheapest	3rd Most expensive
35	8,125,288	8,967,009	3,819,201	4,784,315	198,517	3,008	(£ 20,703,513.)	(£ 18,636,650.)	(£ 22,784,354.)	2nd Cheapest	1st Cheapest	3rd Most expensive
36	9,481,474	10,755,891	4,456,660	5,727,856	238,121	3,608	(£ 24,335,889.)	(£ 21,924,034.)	(£ 26,832,899.)	2nd Cheapest	1st Cheapest	3rd Most expensive
37	10,864,986	12,554,805	5,106,964	6,676,968	277,946	4,211	(£ 28,074,254.)	(£ 25,260,424.)	(£ 30,987,432.)	2nd Cheapest	1st Cheapest	3rd Most expensive
38	12,228,223	14,346,276	5,747,739	7,621,946	317,607	4,812	(£ 31,733,982.)	(£ 28,518,176.)	(£ 35,063,329.)	2nd Cheapest	1st Cheapest	3rd Most expensive
39	13,591,460	16,137,747	6,388,513	8,566,925	357,268	5,413	(£ 35,393,711.)	(£ 31,775,929.)	(£ 39,139,225.)	2nd Cheapest	1st Cheapest	3rd Most expensive
40	14,954,698	17,929,217	7,029,288	9,511,903	396,929	6,014	(£ 39,053,439.)	(£ 35,033,681.)	(£ 43,215,122.)	2nd Cheapest	1st Cheapest	3rd Most expensive
41	16,317,935	19,720,688	7,670,062	10,456,882	436,589	6,615	(£ 42,713,167.)	(£ 38,291,434.)	(£ 47,291,018.)	2nd Cheapest	1st Cheapest	3rd Most expensive
42	17,681,172	21,512,158	8,310,836	11,401,860	476,250	7,216	(£ 46,372,895.)	(£ 41,549,186.)	(£ 51,366,915.)	2nd Cheapest	1st Cheapest	3rd Most expensive
43	19,044,410	23,303,629	8,951,611	12,346,839	515,911	7,817	(£ 50,032,623.)	(£ 44,806,938.)	(£ 55,442,811.)	2nd Cheapest	1st Cheapest	3rd Most expensive
44	20,407,647	25,095,100	9,592,385	13,291,817	555,571	8,418	(£ 53,692,351.)	(£ 48,064,691.)	(£ 59,518,708.)	2nd Cheapest	1st Cheapest	3rd Most expensive
45	21,770,885	26,886,570	10,233,160	14,236,796	595,232	9,019	(£ 57,352,079.)	(£ 51,322,443.)	(£ 63,594,604.)	2nd Cheapest	1st Cheapest	3rd Most expensive
46	3,228,292	2,508,745	1,517,422	1,369,317	55,540	842	(£ 7,967,329.)	(£ 7,434,200.)	(£ 8,219,784.)	2nd Cheapest	1st Cheapest	3rd Most expensive
47	5,094,593	4,988,415	2,394,656	2,668,428	110,437	1,673	(£ 13,222,075.)	(£ 12,155,818.)	(£ 13,829,555.)	2nd Cheapest	1st Cheapest	3rd Most expensive
48	6,958,690	7,467,275	3,270,854	3,967,090	165,315	2,505	(£ 18,567,639.)	(£ 16,877,435.)	(£ 19,430,779.)	2nd Cheapest	1st Cheapest	3rd Most expensive
49	8,849,231	9,955,845	4,159,482	5,271,143	220,409	3,340	(£ 23,983,719.)	(£ 21,701,623.)	(£ 25,134,574.)	2nd Cheapest	1st Cheapest	3rd Most expensive
50	10,751,894	12,448,865	5,053,807	6,577,668	275,601	4,176	(£ 29,446,811.)	(£ 26,683,228.)	(£ 30,885,379.)	2nd Cheapest	1st Cheapest	3rd Most expensive
51	12,637,808	14,935,736	5,940,260	7,880,778	330,657	5,010	(£ 34,844,942.)	(£ 31,528,642.)	(£ 36,571,224.)	2nd Cheapest	1st Cheapest	3rd Most expensive
52	14,523,722	17,422,607	6,826,712	9,183,887	385,713	5,844	(£ 40,243,073.)	(£ 36,374,056.)	(£ 42,257,068.)	2nd Cheapest	1st Cheapest	3rd Most expensive
53	16,409,636	19,909,478	7,713,165	10,486,997	440,769	6,678	(£ 45,641,204.)	(£ 41,219,471.)	(£ 47,942,912.)	2nd Cheapest	1st Cheapest	3rd Most expensive
54	18,295,550	22,396,349	8,599,618	11,790,107	495,825	7,512	(£ 51,039,335.)	(£ 46,064,885.)	(£ 53,628,757.)	2nd Cheapest	1st Cheapest	3rd Most expensive
55	20,181,464	24,883,220	9,486,070	13,093,217	550,881	8,347	(£ 56,437,466.)	(£ 50,910,299.)	(£ 59,314,601.)	2nd Cheapest	1st Cheapest	3rd Most expensive
56	22,067,378	27,370,091	10,372,523	14,396,326	605,937	9,181	(£ 61,835,596.)	(£ 55,755,713.)	(£ 65,000,446.)	2nd Cheapest	1st Cheapest	3rd Most expensive
57	23,953,292	29,856,961	11,258,976	15,699,436	660,993	10,015	(£ 67,233,727.)	(£ 60,601,127.)	(£ 70,686,290.)	2nd Cheapest	1st Cheapest	3rd Most expensive
58	25,839,206	32,343,832	12,145,428	17,002,546	716,049	10,849	(£ 72,631,858.)	(£ 65,446,541.)	(£ 76,372,134.)	2nd Cheapest	1st Cheapest	3rd Most expensive
59	27,725,120	34,830,703	13,031,881	18,305,656	771,104	11,683	(£ 78,029,989.)	(£ 70,291,956.)	(£ 82,057,979.)	2nd Cheapest	1st Cheapest	3rd Most expensive
60	29,611,033	37,317,574	13,918,334	19,608,765	826,160	12,518	(£ 83,428,120.)	(£ 75,137,370.)	(£ 87,743,823.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX H RESULTS WORKSHEET CONTINUED

			Graphed Results		Sensitivities															Fully Automated					
		Test	Pax/Hour	Bags/Hour	# of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflation Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2
High CAPEX Factor	Short Haul Only	61	180	180	1	0	0%	1.1				0.59			3			2		3,675,904	1,524,437	1,727,818	425,999	17,116	259
		62	360	360	2	0	0%	1.1				0.59			3			2		4,763,199	2,976,564	2,238,888	776,399	33,373	506
		63	540	540	3	0	0%	1.1				0.59			3			2		5,850,495	4,428,691	2,749,959	1,126,800	49,631	752
		64	720	720	4	0	0%	1.1				0.59			3			2		6,937,790	5,880,819	3,261,030	1,477,201	65,888	998
		65	900	900	5	0	0%	1.1				0.59			3			2		8,025,085	7,332,946	3,772,101	1,827,601	82,146	1,245
		66	1080	1080	6	0	0%	1.1				0.59			3			2		9,112,380	8,785,073	4,283,172	2,178,002	98,403	1,491
		67	1260	1260	7	0	0%	1.1				0.59			3			2		10,199,675	10,237,200	4,794,243	2,528,403	114,661	1,737
		68	1440	1440	8	0	0%	1.1				0.59			3			2		11,286,970	11,689,328	5,305,313	2,878,803	130,918	1,984
		69	1620	1620	9	0	0%	1.1				0.59			3			2		12,374,265	13,141,455	5,816,384	3,229,204	147,175	2,230
		70	1800	1800	10	0	0%	1.1				0.59			3			2		13,461,560	14,593,582	6,327,455	3,579,605	163,433	2,476
		71	1980	1980	11	0	0%	1.1				0.59			3			2		14,592,510	16,061,737	6,859,045	3,934,779	179,881	2,725
		72	2160	2160	12	0	0%	1.1				0.59			3			2		15,687,509	17,516,693	7,373,737	4,286,022	196,172	2,972
		73	2340	2340	13	0	0%	1.1				0.59			3			2		16,782,507	18,971,649	7,888,429	4,637,265	212,463	3,219
		74	2520	2520	14	0	0%	1.1				0.59			3			2		17,922,701	20,443,198	8,424,364	4,993,451	228,951	3,469
		75	2700	2700	15	0	0%	1.1				0.59			3			2		19,023,863	21,900,416	8,941,953	5,345,368	245,268	3,716
		76	2880	2880	16	0	0%	1.1				0.59			3			2		20,125,025	23,357,635	9,459,542	5,697,285	261,586	3,963
		77	3060	3060	17	0	0%	1.1				0.59			3			2		21,268,917	24,830,542	9,997,215	6,053,875	278,090	4,213
		78	3240	3240	18	0	0%	1.1				0.59			3			2		22,375,009	26,289,570	10,517,122	6,406,331	294,430	4,461
		79	3420	3420	19	0	0%	1.1				0.59			3			2		23,481,101	27,748,599	11,037,028	6,758,787	310,769	4,709
		80	3600	3600	20	0	0%	1.1				0.59			3			2		24,587,193	29,207,628	11,556,934	7,111,244	327,109	4,956
		81	3780	3780	21	0	0%	1.1				0.59			3			2		25,693,285	30,666,656	12,076,840	7,463,700	343,448	5,204
		82	3960	3960	22	0	0%	1.1				0.59			3			2		26,799,377	32,125,685	12,596,746	7,816,156	359,787	5,451
		83	4140	4140	23	0	0%	1.1				0.59			3			2		27,905,470	33,584,714	13,116,652	8,168,612	376,127	5,699
		84	4320	4320	24	0	0%	1.1				0.59			3			2		29,011,562	35,043,742	13,636,559	8,521,068	392,466	5,946
		85	4500	4500	25	0	0%	1.1				0.59			3			2		30,117,654	36,502,771	14,156,465	8,873,525	408,805	6,194
		86	4680	4680	26	0	0%	1.1				0.59			3			2		31,223,746	37,961,800	14,676,371	9,225,981	425,145	6,442
		87	4860	4860	27	0	0%	1.1				0.59			3			2		32,329,838	39,420,828	15,196,277	9,578,437	441,484	6,689
		88	5040	5040	28	0	0%	1.1				0.59			3			2		33,435,930	40,879,857	15,716,183	9,930,893	457,823	6,937
		89	5220	5220	29	0	0%	1.1				0.59			3			2		34,542,023	42,338,886	16,236,090	10,283,350	474,163	7,184
		90	5400	5400	30	0	0%	1.1				0.59			3			2		35,648,115	43,797,914	16,755,996	10,635,806	490,502	7,432
	Long Haul Only	91	400	480	0	1	0%	1.1				0.59			3			2		5,338,023	2,843,111	2,509,078	990,713	32,446	492
		92	800	960	0	2	0%	1.1				0.59			3			2		8,087,437	5,613,913	3,801,409	1,905,828	64,033	970
		93	1200	1440	0	3	0%	1.1				0.59			3			2		10,836,851	8,384,715	5,093,740	2,820,943	95,620	1,449
		94	1600	1920	0	4	0%	1.1				0.59			3			2		13,627,351	11,170,602	6,405,383	3,740,551	127,387	1,930
		95	2000	2400	0	5	0%	1.1				0.59			3			2		16,438,395	13,964,032	7,726,683	4,662,406	159,243	2,413
		96	2400	2880	0	6	0%	1.1				0.59			3			2		19,224,786	16,748,410	9,036,395	5,581,564	190,991	2,894
		97	2800	3360	0	7	0%	1.1				0.59			3			2		22,062,125	19,551,494	10,370,054	6,506,295	222,962	3,378
		98	3200	3840	0	8	0%	1.1				0.59			3			2		24,861,665	22,340,700	11,685,946	7,426,891	254,768	3,860
		99	3600	4320	0	9	0%	1.1				0.59			3			2		27,661,204	25,129,906	13,001,838	8,347,488	286,574	4,342
		100	4000	4800	0	10	0%	1.1				0.59			3			2		30,460,744	27,919,111	14,317,730	9,268,084	318,379	4,824
		101	4400	5280	0	11	0%	1.1				0.59			3			2		33,260,283	30,708,317	15,633,622	10,188,681	350,185	5,306
		102	4800	5760	0	12	0%	1.1				0.59			3			2		36,059,822	33,497,523	16,949,514	11,109,277	381,991	5,788
		103	5200	6240	0	13	0%	1.1				0.59			3			2		38,859,362	36,286,728	18,265,406	12,029,874	413,797	6,270
		104	5600	6720	0	14	0%	1.1				0.59			3			2		41,658,901	39,075,934	19,581,298	12,950,470	445,603	6,752
		105	6000	7200	0	15	0%	1.1				0.59			3			2		44,458,440	41,865,140	20,897,190	13,871,067	477,408	7,233
	Short Haul and Long Haul Mix	106	580	660	1	1	0%	1.1				0.59			3			2		6,425,318	4,295,239	3,020,149	1,341,114	48,703	738
		107	1160	1320	2	2	0%	1.1				0.59			3			2		10,262,027	8,518,168	4,823,551	2,606,629	96,548	1,463
		108	1740	1980	3	3	0%	1.1				0.59			3			2		14,142,390	12,757,125	6,647,472	3,876,919	144,583	2,191
		109	2320	2640	4	4	0%	1.1				0.59			3			2		18,056,650	17,008,527	8,487,326	5,150,915	192,766	2,921
		110	2900	3300	5	5	0%	1.1				0.59			3			2		21,993,507	21,268,226	10,337,801	6,427,383	241,047	3,652
		111	3480	3960	6	6	0%	1.1				0.59			3			2		25,899,139	25,516,460	12,173,599	7,700,435	289,192	4,382
		112	4060	4620	7	7	0%	1.1				0.59			3			2		29,804,771	29,764,695	14,009,398	8,973,488	337,338	5,111
		113	4640	5280	8	8	0%	1.1				0.59			3			2		33,710,402	34,012,929	15,845,196	10,246,541	385,483	5,841
		114	5220	5940	9	9	0%	1.1				0.59			3			2		37,616,034	38,261,163	17,680,994	11,519,594	433,628	6,570
		115	5800	6600	10	10	0%	1.1				0.59			3			2		41,521,665	42,509,398	19,516,792	12,792,646	481,773	7,300
		116	6380	7260	11	11	0%	1.1				0.59			3			2		45,427,297	46,757,632	21,352,590	14,065,699	529,918	8,029
		117	6960	7920	12	12	0%	1.1				0.59			3			2		49,332,928	51,005,866	23,188,389	15,338,752	578,063	8,759
		118	7540	8580	13	13	0%	1.1				0.59			3			2		53,238,560	55,254,101	25,024,187	16,611,805	626,209	9,488
		119	8120	9240	14	14	0%	1.1				0.59			3			2		57,144,191	59,502,335	26,859,985	17,884,857	674,354	10,217
		120	8700	9900	15	15	0%	1.1				0.59			3			2		61,049,823	63,750,569	28,695,783	19,157,910	722,499	10,947

	Semi Automated						Manual						Result and Ranking: Graphed Results			Ranking Results		
Test	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
61	3,589,348	1,494,356	1,687,133	419,744	16,825	255	3,539,672	1,360,220	1,663,783	431,168	16,152	245	(£ 7,389,536.)	(£ 7,176,522.)	(£ 7,094,814.)	3rd Most expensive	2nd Cheapest	1st Cheapest
62	4,590,087	2,916,402	2,157,519	763,890	32,790	497	4,490,734	2,648,130	2,110,819	786,739	31,445	476	(£ 10,399,907.)	(£ 9,973,879.)	(£ 9,810,462.)	3rd Most expensive	2nd Cheapest	1st Cheapest
63	5,590,826	4,338,448	2,627,905	1,108,035	48,756	739	5,441,797	3,936,041	2,557,855	1,142,309	46,738	708	(£ 13,410,277.)	(£ 12,771,235.)	(£ 12,526,110.)	3rd Most expensive	2nd Cheapest	1st Cheapest
64	6,591,565	5,760,494	3,098,291	1,452,181	64,722	981	6,392,859	5,223,952	3,004,892	1,497,879	62,031	940	(£ 16,420,648.)	(£ 15,568,591.)	(£ 15,241,758.)	3rd Most expensive	2nd Cheapest	1st Cheapest
65	7,592,305	7,182,541	3,568,677	1,796,327	80,688	1,223	7,343,922	6,511,862	3,451,928	1,853,450	77,324	1,172	(£ 19,431,018.)	(£ 18,365,947.)	(£ 17,957,406.)	3rd Most expensive	2nd Cheapest	1st Cheapest
66	8,593,044	8,604,587	4,039,064	2,140,473	96,654	1,464	8,294,984	7,799,773	3,898,964	2,209,020	92,617	1,403	(£ 22,441,388.)	(£ 21,163,304.)	(£ 20,673,054.)	3rd Most expensive	2nd Cheapest	1st Cheapest
67	9,593,783	10,026,633	4,509,450	2,484,618	112,620	1,706	9,291,242	9,104,277	4,367,244	2,569,532	108,107	1,638	(£ 25,451,759.)	(£ 23,960,660.)	(£ 23,518,411.)	3rd Most expensive	2nd Cheapest	1st Cheapest
68	10,594,522	11,448,679	4,979,836	2,828,764	128,586	1,948	10,254,630	10,396,713	4,820,074	2,926,451	123,454	1,871	(£ 28,462,129.)	(£ 26,758,016.)	(£ 26,269,434.)	3rd Most expensive	2nd Cheapest	1st Cheapest
69	11,595,261	12,870,725	5,450,222	3,172,910	144,552	2,190	11,218,019	11,689,149	5,272,904	3,283,369	138,801	2,103	(£ 31,472,500.)	(£ 29,555,373.)	(£ 29,020,457.)	3rd Most expensive	2nd Cheapest	1st Cheapest
70	12,596,000	14,292,772	5,920,608	3,517,056	160,518	2,432	12,181,407	12,981,585	5,725,734	3,640,287	154,148	2,336	(£ 34,482,870.)	(£ 32,352,729.)	(£ 31,771,480.)	3rd Most expensive	2nd Cheapest	1st Cheapest
71	13,596,739	15,714,818	6,390,994	3,861,202	176,484	2,674	13,144,795	14,274,021	6,178,563	3,997,205	169,495	2,568	(£ 37,618,528.)	(£ 35,150,085.)	(£ 34,522,504.)	3rd Most expensive	2nd Cheapest	1st Cheapest
72	14,597,478	17,136,864	6,861,381	4,205,347	192,450	2,916	14,108,184	15,566,457	6,631,393	4,354,123	184,842	2,801	(£ 40,651,007.)	(£ 37,947,442.)	(£ 37,273,527.)	3rd Most expensive	2nd Cheapest	1st Cheapest
73	15,598,217	18,558,910	7,331,767	4,549,493	208,416	3,158	15,071,572	16,858,893	7,084,223	4,711,042	200,189	3,033	(£ 43,683,487.)	(£ 40,744,798.)	(£ 40,024,550.)	3rd Most expensive	2nd Cheapest	1st Cheapest
74	16,644,151	19,997,550	7,823,396	4,898,581	224,579	3,403	16,080,156	18,167,922	7,558,297	5,072,902	215,732	3,269	(£ 46,845,676.)	(£ 43,671,863.)	(£ 42,905,282.)	3rd Most expensive	2nd Cheapest	1st Cheapest
75	17,651,053	21,421,859	8,296,679	5,243,401	240,572	3,645	17,049,707	19,462,621	8,014,023	5,430,494	231,106	3,502	(£ 49,895,844.)	(£ 46,486,907.)	(£ 45,673,993.)	3rd Most expensive	2nd Cheapest	1st Cheapest
76	18,699,042	22,861,253	8,789,275	5,592,714	256,743	3,890	18,019,259	20,757,320	8,469,750	5,788,087	246,480	3,735	(£ 52,946,011.)	(£ 49,419,868.)	(£ 48,442,704.)	3rd Most expensive	2nd Cheapest	1st Cheapest
77	19,753,810	24,303,136	9,285,056	5,942,768	272,945	4,136	19,031,540	22,067,707	8,945,562	6,150,351	262,040	3,970	(£ 56,118,813.)	(£ 52,372,286.)	(£ 51,334,049.)	3rd Most expensive	2nd Cheapest	1st Cheapest
78	20,770,778	25,731,141	9,763,071	6,288,688	288,982	4,379	20,006,022	23,364,216	9,403,606	6,508,483	277,435	4,204	(£ 59,183,131.)	(£ 55,216,220.)	(£ 54,116,909.)	3rd Most expensive	2nd Cheapest	1st Cheapest
79	21,787,746	27,159,146	10,241,085	6,634,609	305,018	4,621	20,980,504	24,660,725	9,861,650	6,866,614	292,830	4,437	(£ 62,247,448.)	(£ 58,060,153.)	(£ 56,899,770.)	3rd Most expensive	2nd Cheapest	1st Cheapest
80	22,804,714	28,587,150	10,719,100	6,980,529	321,055	4,864	21,954,985	25,957,234	10,319,694	7,224,745	308,226	4,670	(£ 65,311,766.)	(£ 60,904,087.)	(£ 59,682,631.)	3rd Most expensive	2nd Cheapest	1st Cheapest
81	23,821,683	30,015,155	11,197,114	7,326,450	337,092	5,107	22,929,467	27,253,743	10,777,738	7,582,877	323,621	4,903	(£ 68,376,083.)	(£ 63,748,021.)	(£ 62,465,492.)	3rd Most expensive	2nd Cheapest	1st Cheapest
82	24,838,651	31,443,160	11,675,129	7,672,370	353,128	5,350	23,903,949	28,550,252	11,235,783	7,941,008	339,016	5,137	(£ 71,440,401.)	(£ 66,591,954.)	(£ 65,248,353.)	3rd Most expensive	2nd Cheapest	1st Cheapest
83	25,855,619	32,871,165	12,153,143	8,018,291	369,165	5,593	24,878,431	29,846,761	11,693,827	8,299,139	354,411	5,370	(£ 74,504,719.)	(£ 69,435,888.)	(£ 68,031,214.)	3rd Most expensive	2nd Cheapest	1st Cheapest
84	26,872,587	34,299,169	12,631,158	8,364,211	385,202	5,836	25,852,913	31,143,270	12,151,871	8,657,271	369,806	5,603	(£ 77,569,036.)	(£ 72,279,822.)	(£ 70,814,075.)	3rd Most expensive	2nd Cheapest	1st Cheapest
85	27,889,555	35,727,174	13,109,172	8,710,132	401,238	6,079	26,827,394	32,439,779	12,609,915	9,015,402	385,202	5,836	(£ 80,633,354.)	(£ 75,123,755.)	(£ 73,596,936.)	3rd Most expensive	2nd Cheapest	1st Cheapest
86	28,906,524	37,155,179	13,587,187	9,056,052	417,275	6,322	27,801,876	33,736,287	13,067,960	9,373,533	400,597	6,070	(£ 83,697,671.)	(£ 77,967,689.)	(£ 76,379,796.)	3rd Most expensive	2nd Cheapest	1st Cheapest
87	29,923,492	38,583,184	14,065,201	9,401,973	433,312	6,565	28,776,358	35,032,796	13,526,004	9,731,665	415,992	6,303	(£ 86,761,989.)	(£ 80,811,623.)	(£ 79,162,657.)	3rd Most expensive	2nd Cheapest	1st Cheapest
88	30,940,460	40,011,189	14,543,216	9,747,893	449,349	6,808	29,750,840	36,329,305	13,984,048	10,089,796	431,387	6,536	(£ 89,826,307.)	(£ 83,655,556.)	(£ 81,945,518.)	3rd Most expensive	2nd Cheapest	1st Cheapest
89	31,957,428	41,439,193	15,021,230	10,093,814	465,385	7,051	30,725,322	37,625,814	14,442,092	10,447,927	446,783	6,769	(£ 92,890,624.)	(£ 86,499,490.)	(£ 84,728,379.)	3rd Most expensive	2nd Cheapest	1st Cheapest
90	32,974,397	42,867,198	15,499,245	10,439,734	481,422	7,294	31,699,803	38,922,323	14,900,136	10,806,059	462,178	7,003	(£ 95,954,942.)	(£ 89,343,424.)	(£ 87,511,240.)	3rd Most expensive	2nd Cheapest	1st Cheapest
91	5,107,207	2,762,895	2,400,585	974,033	31,669	480	5,067,787	3,389,410	2,382,056	1,013,747	40,247	610	(£ 10,862,581.)	(£ 10,294,544.)	(£ 11,317,164.)	2nd Cheapest	1st Cheapest	3rd Most expensive
92	7,625,805	5,453,481	3,584,424	1,872,469	62,479	947	7,546,964	6,706,511	3,547,366	1,951,896	79,636	1,207	(£ 17,345,997.)	(£ 16,209,922.)	(£ 18,255,161.)	2nd Cheapest	1st Cheapest	3rd Most expensive
93	10,144,403	8,144,067	4,768,262	2,770,904	93,289	1,413	10,083,663	10,044,731	4,739,712	2,896,335	119,275	1,807	(£ 23,829,412.)	(£ 22,125,300.)	(£ 25,358,243.)	2nd Cheapest	1st Cheapest	3rd Most expensive
94	12,663,000	10,834,653	5,952,101	3,669,339	124,099	1,880	12,595,710	13,373,900	5,920,472	3,838,079	158,807	2,406	(£ 30,430,745.)	(£ 28,040,678.)	(£ 32,390,575.)	2nd Cheapest	1st Cheapest	3rd Most expensive
95	15,222,685	13,540,324	7,155,252	4,572,267	155,088	2,350	15,148,843	16,718,153	7,120,543	4,784,315	198,517	3,008	(£ 37,091,037.)	(£ 34,073,973.)	(£ 39,540,823.)	2nd Cheapest	1st Cheapest	3rd Most expensive
96	17,798,803	16,252,029	8,366,128	5,476,993	186,149	2,820	17,677,324	20,053,356	8,309,028	5,727,856	238,121	3,608	(£ 43,680,578.)	(£ 40,154,435.)	(£ 46,620,322.)	2nd Cheapest	1st Cheapest	3rd Most expensive
97	20,398,478	18,972,382	9,588,076	6,384,295	217,312	3,293	20,256,753	23,407,264	9,521,459	6,676,968	277,946	4,211	(£ 50,416,337.)	(£ 46,302,503.)	(£ 53,846,038.)	2nd Cheapest	1st Cheapest	3rd Most expensive
98	22,960,354	21,678,857	10,792,256	7,287,462	248,311	3,762	22,798,382	26,747,294	10,716,123	7,621,946	317,607	4,812	(£ 57,043,611.)	(£ 52,342,087.)	(£ 60,963,270.)	2nd Cheapest	1st Cheapest	3rd Most expensive
99	25,522,230	24,385,333	11,996,437	8,190,630	279,309	4,232	25,340,011	30,087,324	11,910,787	8,566,925	357,268	5,413	(£ 63,670,886.)	(£ 58,381,672.)	(£ 68,080,502.)	2nd Cheapest	1st Cheapest	3rd Most expensive
100	28,084,105	27,091,808	13,200,618	9,093,798	310,308	4,702	27,881,640	33,427,354	13,105,452	9,511,903	396,929	6,014	(£ 70,298,161.)	(£ 64,421,256.)	(£ 75,197,734.)	2nd Cheapest	1st Cheapest	3rd Most expensive
101	30,645,981	29,798,283	14,404,799	9,996,966	341,307	5,171	30,423,269	36,767,384	14,300,116	10,456,882	436,589	6,615	(£ 76,925,435.)	(£ 70,460,840.)	(£ 82,314,966.)	2nd Cheapest	1st Cheapest	3rd Most expensive
102	33,207,856	32,504,759	15,608,980	10,900,134	372,305	5,641	32,964,898	40,107,414	15,494,780	11,401,860	476,250	7,216	(£ 83,552,710.)	(£ 76,500,424.)	(£ 89,432,198.)	2nd Cheapest	1st Cheapest	3rd Most expensive
103	35,769,732	35,211,234	16,813,161	11,803,302	403,304	6,111	35,506,527	43,447,444	16,689,444	12,346,839	515,911	7,817	(£ 90,179,985.)	(£ 82,540,009.)	(£ 96,549,430.)	2nd Cheapest	1st Cheapest	3rd Most expensive
104	38,331,607	37,917,710	18,017,341	12,706,470	434,303	6,580	38,048,156	46,787,474	17,884,108	13,291,817	555,571	8,418	(£ 96,807,260.)	(£ 88,579,593.)	(£ 103,666,662.)	2nd Cheapest	1st Cheapest	3rd Most expensive
105	40,893,483	40,624,185	19,221,522	13,609,638	465,301	7,050	40,589,785	50,127,504	19,078,772	14,236,796	595,232	9,019	(£ 103,434,534.)	(£ 94,619,177.)	(£ 110,783,894.)	2nd Cheapest	1st Cheapest	3rd Most expensive
106	6,107,946	4,184,941	2,870,971	1,318,179	47,635	722	6,018,849	4,677,321	2,829,092	1,369,317	55,540	842	(£ 13,872,952.)	(£ 13,091,900.)	(£ 14,032,812.)	2nd Cheapest	1st Cheapest	3rd Most expensive
107	9,627,283	8,297,574	4,525,196	2,560,760	94,410	1,430	9,498,393	9,300,434	4,464,613	2,668,428	110,437	1,673	(£ 23,366,738.)	(£ 21,804,634.)	(£ 23,827,958.)	2nd Cheapest	1st Cheapest	3rd Most expensive
108	13,146,620	12,410,206	6,179,421	3,803,341	141,186	2,139	12,973,828	13,922,039	6,098,202	3,967,090	165,315	2,505	(£ 32,985,811.)	(£ 30,517,369.)	(£ 33,611,313.)	2nd Cheapest	1st Cheapest	3rd Most expensive
109	16,715,260	16,540,940	7,856,820	5,051,314	188,177	2,851	16,498,567	18,561,746	7,754,966	5,271,143	220,409	3,340	(£ 42,702,166.)	(£ 39,371,604.)	(£ 43,536,168.)	2nd Cheapest	1st Cheapest	3rd Most expensive
110	20,359,569	20,699,455	9,569,786	6,307,561	235,498	3,568	20,045,904	23,209,749	9,422,352	6,577,668	275,601	4,176	(£ 52,483,375.)	(£ 48,443,003.)	(£ 53,525,878.)	2nd Cheapest	1st Cheapest	3rd Most expensive
111	23,938,412	24,833,935	11,251,982	7,556,650	282,533	4,281	23,562,014	27,846,288	11,075,060	7,880,778	330,657	5,010	(£ 62,174,968.)	(£ 57,326,521.)	(£ 63,425,971.)	2nd Cheapest	1st Cheapest	3rd Most expensive
112	27,517,256	28,968,416	12,934,177	8,805,738	329,569	4,993	27,078,125	32,482,827	12,727,769	9,183,887	385,713	5,844	(£ 71,866,560.)	(£ 66,210,039.)	(£ 73,326,064.)	2nd Cheapest	1st Cheapest	3rd Most expensive
113	31,096,100	33,102,896	14,616,372	10,054,827	376,604	5,706	30,594,236	37,119,366	14,380,477	10,486,997	440,769	6,678	(£ 81,558,152.)	(£ 75,093,557.)	(£ 83,226,157.)	2nd Cheapest	1st Cheapest	3rd Most expensive
114	34,674,944	37,237,376	16,298,568	11,303,915	423,640	6,419	34,110,347	41,755,905	16,033,185	11,790,107	495,825	7,512	(£ 91,249,744.)	(£ 83,977,075.)	(£ 93,126,250.)	2nd Cheapest	1st Cheapest	3rd Most expensive
115	38,253,787	41,371,856	17,980,763	12,553,003	470,675	7,131	37,626,458	46,392,444	17,685,894	13,093,217	550,881	8,347	(£ 100,941,337.)	(£ 92,860,593.)	(£ 103,026,343.)	2nd Cheapest	1st Cheapest	3rd Most expensive
116	41,832,631	45,506,336	19,662,958	13,802,092	517,710	7,844	41,142,568	51,028,982	19,338,602	14,396,326	605,937	9,181	(£ 110,632,929.)	(£ 101,744,110.)	(£ 112,926,436.)	2nd Cheapest	1st Cheapest	3rd Most expensive
117	45,411,475	49,640,816	21,345,154	15,051,180	564,746	8,557	44,658,679	55,665,521	20,991,310	15,699,436	660,993	10,015	(£ 120,324,521.)	(£ 110,627,628.)	(£ 122,826,529.)	2nd Cheapest	1st Cheapest	3rd Most expensive
118	48,990,319	53,775,296	23,027,349	16,300,269	611,781	9,269	48,174,790	60,302,060	22,644,019	17,002,546	716,049	10,849	(£ 130,016,114.)	(£ 119,511,146.)	(£ 132,726,621.)	2nd Cheapest	1st Cheapest	3rd Most expensive
119	52,569,162	57,909,777	24,709,544	17,549,357	658,816	9,982	51,690,901	64,938,599	24,296,727	18,305,656	771,104	11,683	(£ 139,707,706.)	(£ 128,394,664.)	(£ 142,626,714.)	2nd Cheapest	1st Cheapest	3rd Most expensive
120	56,148,006	62,044,257	26,391,739	18,798,446	705,852	10,695	55,207,012	69,575,138	25,949,436	19,608,765	826,160	12,518	(£ 149,399,298.)	(£ 137,278,182.)	(£ 152,526,807.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX H RESULTS WORKSHEET CONTINUED

		Test	Pax/Hour	Bags/Hour	# of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflatin Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min
			Graphed Results		Sensitivities														
Low CAPEX Factor	Short Haul Only	121	180	180	1	0	0%			0.19		0.59			3			2	
		122	360	360	2	0	0%			0.19		0.59			3			2	
		123	540	540	3	0	0%			0.19		0.59			3			2	
		124	720	720	4	0	0%			0.19		0.59			3			2	
		125	900	900	5	0	0%			0.19		0.59			3			2	
		126	1080	1080	6	0	0%			0.19		0.59			3			2	
		127	1260	1260	7	0	0%			0.19		0.59			3			2	
		128	1440	1440	8	0	0%			0.19		0.59			3			2	
		129	1620	1620	9	0	0%			0.19		0.59			3			2	
		130	1800	1800	10	0	0%			0.19		0.59			3			2	
		131	1980	1980	11	0	0%			0.19		0.59			3			2	
		132	2160	2160	12	0	0%			0.19		0.59			3			2	
		133	2340	2340	13	0	0%			0.19		0.59			3			2	
		134	2520	2520	14	0	0%			0.19		0.59			3			2	
		135	2700	2700	15	0	0%			0.19		0.59			3			2	
		136	2880	2880	16	0	0%			0.19		0.59			3			2	
		137	3060	3060	17	0	0%			0.19		0.59			3			2	
		138	3240	3240	18	0	0%			0.19		0.59			3			2	
		139	3420	3420	19	0	0%			0.19		0.59			3			2	
		140	3600	3600	20	0	0%			0.19		0.59			3			2	
		141	3780	3780	21	0	0%			0.19		0.59			3			2	
		142	3960	3960	22	0	0%			0.19		0.59			3			2	
		143	4140	4140	23	0	0%			0.19		0.59			3			2	
		144	4320	4320	24	0	0%			0.19		0.59			3			2	
		145	4500	4500	25	0	0%			0.19		0.59			3			2	
		146	4680	4680	26	0	0%			0.19		0.59			3			2	
		147	4860	4860	27	0	0%			0.19		0.59			3			2	
		148	5040	5040	28	0	0%			0.19		0.59			3			2	
		149	5220	5220	29	0	0%			0.19		0.59			3			2	
		150	5400	5400	30	0	0%			0.19		0.59			3			2	
	Long Haul Only	151	400	480	0	1	0%			0.19		0.59			3			2	
		152	800	960	0	2	0%			0.19		0.59			3			2	
		153	1200	1440	0	3	0%			0.19		0.59			3			2	
		154	1600	1920	0	4	0%			0.19		0.59			3			2	
		155	2000	2400	0	5	0%			0.19		0.59			3			2	
		156	2400	2880	0	6	0%			0.19		0.59			3			2	
		157	2800	3360	0	7	0%			0.19		0.59			3			2	
		158	3200	3840	0	8	0%			0.19		0.59			3			2	
		159	3600	4320	0	9	0%			0.19		0.59			3			2	
		160	4000	4800	0	10	0%			0.19		0.59			3			2	
		161	4400	5280	0	11	0%			0.19		0.59			3			2	
		162	4800	5760	0	12	0%			0.19		0.59			3			2	
		163	5200	6240	0	13	0%			0.19		0.59			3			2	
		164	5600	6720	0	14	0%			0.19		0.59			3			2	
		165	6000	7200	0	15	0%			0.19		0.59			3			2	
	Short Haul and Long Haul Mix	166	580	660	1	1	0%			0.19		0.59			3			2	
		167	1160	1320	2	2	0%			0.19		0.59			3			2	
		168	1740	1980	3	3	0%			0.19		0.59			3			2	
		169	2320	2640	4	4	0%			0.19		0.59			3			2	
		170	2900	3300	5	5	0%			0.19		0.59			3			2	
		171	3480	3960	6	6	0%			0.19		0.59			3			2	
		172	4060	4620	7	7	0%			0.19		0.59			3			2	
		173	4640	5280	8	8	0%			0.19		0.59			3			2	
		174	5220	5940	9	9	0%			0.19		0.59			3			2	
		175	5800	6600	10	10	0%			0.19		0.59			3			2	
		176	6380	7260	11	11	0%			0.19		0.59			3			2	
		177	6960	7920	12	12	0%			0.19		0.59			3			2	
		178	7540	8580	13	13	0%			0.19		0.59			3			2	
		179	8120	9240	14	14	0%			0.19		0.59			3			2	
		180	8700	9900	15	15	0%			0.19		0.59			3			2	

Test	Fully Automated: Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	Semi Automated: Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2
121	634,929	263,312	298,441	425,999	17,116	259	619,978	258,116	291,414	419,744	16,825	255
122	822,734	514,134	386,717	776,399	33,373	506	792,833	503,742	372,662	763,890	32,790	497
123	1,010,540	764,956	474,993	1,126,800	49,631	752	965,688	749,368	453,911	1,108,035	48,756	739
124	1,198,345	1,015,778	563,269	1,477,201	65,888	998	1,138,543	994,994	535,159	1,452,181	64,722	981
125	1,386,151	1,266,600	651,545	1,827,601	82,146	1,245	1,311,398	1,240,621	616,408	1,796,327	80,688	1,223
126	1,573,957	1,517,422	739,821	2,178,002	98,403	1,491	1,484,253	1,486,247	697,656	2,140,473	96,654	1,464
127	1,761,762	1,768,244	828,096	2,528,403	114,661	1,737	1,657,108	1,731,873	778,905	2,484,618	112,620	1,706
128	1,949,568	2,019,066	916,372	2,878,803	130,918	1,984	1,829,963	1,977,499	860,153	2,828,764	128,586	1,948
129	2,137,373	2,269,888	1,004,648	3,229,204	147,175	2,230	2,002,818	2,223,125	941,402	3,172,910	144,552	2,190
130	2,325,179	2,520,710	1,092,924	3,579,605	163,433	2,476	2,175,673	2,468,751	1,022,651	3,517,056	160,518	2,432
131	2,520,524	2,774,300	1,184,744	3,934,779	179,881	2,725	2,348,528	2,714,378	1,103,899	3,861,202	176,484	2,674
132	2,709,661	3,025,611	1,273,646	4,286,022	196,172	2,972	2,521,383	2,960,004	1,185,148	4,205,347	192,450	2,916
133	2,898,797	3,276,921	1,362,547	4,637,265	212,463	3,219	2,694,237	3,205,630	1,266,396	4,549,493	208,416	3,158
134	3,095,739	3,531,098	1,455,117	4,993,451	228,951	3,469	2,874,899	3,454,122	1,351,314	4,898,581	224,579	3,403
135	3,285,940	3,782,799	1,544,519	5,345,368	245,268	3,716	3,048,818	3,700,139	1,433,063	5,243,401	240,572	3,645
136	3,476,141	4,034,501	1,633,921	5,697,285	261,586	3,963	3,229,834	3,948,762	1,518,147	5,592,714	256,743	3,890
137	3,673,722	4,288,912	1,726,792	6,053,875	278,090	4,213	3,412,022	4,197,814	1,603,782	5,942,768	272,945	4,136
138	3,864,774	4,540,926	1,816,594	6,406,331	294,430	4,461	3,587,680	4,444,470	1,686,349	6,288,688	288,982	4,379
139	4,055,827	4,792,940	1,906,396	6,758,787	310,769	4,709	3,763,338	4,691,125	1,768,915	6,634,609	305,018	4,621
140	4,246,879	5,044,954	1,996,198	7,111,244	327,109	4,956	3,938,996	4,937,781	1,851,481	6,980,529	321,055	4,864
141	4,437,931	5,296,968	2,086,000	7,463,700	343,448	5,204	4,114,654	5,184,436	1,934,047	7,326,450	337,092	5,107
142	4,628,983	5,548,982	2,175,802	7,816,156	359,787	5,451	4,290,312	5,431,091	2,016,613	7,672,370	353,128	5,350
143	4,820,036	5,800,996	2,265,604	8,168,612	376,127	5,699	4,465,971	5,677,747	2,099,179	8,018,291	369,165	5,593
144	5,011,088	6,053,010	2,355,406	8,521,068	392,466	5,946	4,641,629	5,924,402	2,181,745	8,364,211	385,202	5,836
145	5,202,140	6,305,024	2,445,208	8,873,525	408,805	6,194	4,817,287	6,171,057	2,264,312	8,710,132	401,238	6,079
146	5,393,193	6,557,038	2,535,010	9,225,981	425,145	6,442	4,992,945	6,417,713	2,346,878	9,056,052	417,275	6,322
147	5,584,245	6,809,052	2,624,812	9,578,437	441,484	6,689	5,168,603	6,664,368	2,429,444	9,401,973	433,312	6,565
148	5,775,297	7,061,066	2,714,614	9,930,893	457,823	6,937	5,344,261	6,911,023	2,512,010	9,747,893	449,349	6,808
149	5,966,349	7,313,080	2,804,415	10,283,350	474,163	7,184	5,519,919	7,157,679	2,594,576	10,093,814	465,385	7,051
150	6,157,402	7,565,094	2,894,217	10,635,806	490,502	7,432	5,695,578	7,404,334	2,677,142	10,439,734	481,422	7,294
151	922,022	491,083	433,386	990,713	32,446	492	882,154	477,227	414,647	974,033	31,669	480
152	1,396,921	969,676	656,607	1,905,828	64,033	970	1,317,184	941,965	619,128	1,872,469	62,479	947
153	1,871,820	1,448,269	879,828	2,820,943	95,620	1,449	1,752,215	1,406,702	823,609	2,770,904	93,289	1,413
154	2,353,815	1,929,468	1,106,384	3,740,551	127,387	1,930	2,187,246	1,871,440	1,028,090	3,669,339	124,099	1,880
155	2,839,359	2,411,969	1,334,609	4,662,406	159,243	2,413	2,629,373	2,338,783	1,235,907	4,572,267	155,088	2,350
156	3,320,645	2,892,907	1,560,832	5,581,564	190,991	2,894	3,074,339	2,807,169	1,445,058	5,476,993	186,149	2,820
157	3,810,731	3,377,076	1,791,191	6,506,295	222,962	3,378	3,523,374	3,277,048	1,656,122	6,384,295	217,312	3,293
158	4,294,288	3,858,848	2,018,482	7,426,891	254,768	3,860	3,965,879	3,744,530	1,864,117	7,287,462	248,311	3,762
159	4,777,844	4,340,620	2,245,772	8,347,488	286,574	4,342	4,408,385	4,212,012	2,072,112	8,190,630	279,309	4,232
160	5,261,401	4,822,392	2,473,063	9,268,084	318,379	4,824	4,850,891	4,679,494	2,280,107	9,093,798	310,308	4,702
161	5,744,958	5,304,164	2,700,353	10,188,681	350,185	5,306	5,293,397	5,146,976	2,488,102	9,996,966	341,307	5,171
162	6,228,515	5,785,936	2,927,643	11,109,277	381,991	5,788	5,735,902	5,614,458	2,696,096	10,900,134	372,305	5,641
163	6,712,072	6,267,708	3,154,934	12,029,874	413,797	6,270	6,178,408	6,081,940	2,904,091	11,803,302	403,304	6,111
164	7,195,628	6,749,479	3,382,224	12,950,470	445,603	6,752	6,620,914	6,549,423	3,112,086	12,706,470	434,303	6,580
165	7,679,185	7,231,251	3,609,515	13,871,067	477,408	7,233	7,063,420	7,016,905	3,320,081	13,609,638	465,301	7,050
166	1,109,828	741,905	521,662	1,341,114	48,703	738	1,055,009	722,854	495,895	1,318,179	47,635	722
167	1,772,532	1,471,320	833,159	2,606,629	96,548	1,463	1,662,894	1,433,217	781,625	2,560,760	94,410	1,430
168	2,442,777	2,203,503	1,148,200	3,876,919	144,583	2,191	2,270,780	2,143,581	1,067,355	3,803,341	141,186	2,139
169	3,118,876	2,937,837	1,465,993	5,150,915	192,766	2,921	2,887,181	2,857,071	1,357,087	5,051,314	188,177	2,851
170	3,798,879	3,673,603	1,785,620	6,427,383	241,047	3,652	3,516,653	3,575,360	1,652,963	6,307,561	235,498	3,568
171	4,473,488	4,407,389	2,102,713	7,700,435	289,192	4,382	4,134,817	4,289,498	1,943,524	7,556,650	282,533	4,281
172	5,148,097	5,141,175	2,419,805	8,973,488	337,338	5,111	4,752,981	5,003,635	2,234,085	8,805,738	329,569	4,993
173	5,822,706	5,874,960	2,736,897	10,246,541	385,483	5,841	5,371,145	5,717,773	2,524,646	10,054,827	376,604	5,706
174	6,497,315	6,608,746	3,053,990	11,519,594	433,628	6,570	5,989,308	6,431,910	2,815,207	11,303,915	423,640	6,419
175	7,171,924	7,342,532	3,371,082	12,792,646	481,773	7,300	6,607,472	7,146,048	3,105,768	12,553,003	470,675	7,131
176	7,846,533	8,076,318	3,688,175	14,065,699	529,918	8,029	7,225,636	7,860,185	3,396,329	13,802,092	517,710	7,844
177	8,521,142	8,810,104	4,005,267	15,338,752	578,063	8,759	7,843,800	8,574,323	3,686,890	15,051,180	564,746	8,557
178	9,195,751	9,543,890	4,322,360	16,611,805	626,209	9,488	8,461,964	9,288,460	3,977,451	16,300,269	611,781	9,269
179	9,870,360	10,277,676	4,639,452	17,884,857	674,354	10,217	9,080,128	10,002,598	4,268,012	17,549,357	658,816	9,982
180	10,544,969	11,011,462	4,956,544	19,157,910	722,499	10,947	9,698,292	10,716,735	4,558,573	18,798,446	705,852	10,695

Test	Manual: Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	Result and Ranking – Graphed Results: WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	Ranking Results: WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
121	611,398	234,947	287,381	431,168	16,152	245	(£ 2,076,464.)	(£ 1,984,097.)	(£ 2,061,258.)	3rd Most expensive	1st Cheapest	2nd Cheapest
122	775,672	457,404	364,596	786,739	31,445	476	(£ 2,747,470.)	(£ 2,562,736.)	(£ 2,717,056.)	3rd Most expensive	1st Cheapest	2nd Cheapest
123	939,947	679,862	441,811	1,142,309	46,738	708	(£ 3,418,475.)	(£ 3,141,374.)	(£ 3,372,855.)	3rd Most expensive	1st Cheapest	2nd Cheapest
124	1,104,221	902,319	519,027	1,497,879	62,031	940	(£ 4,089,481.)	(£ 3,720,013.)	(£ 4,028,654.)	3rd Most expensive	1st Cheapest	2nd Cheapest
125	1,268,496	1,124,776	596,242	1,853,450	77,324	1,172	(£ 4,760,486.)	(£ 4,298,651.)	(£ 4,684,453.)	3rd Most expensive	1st Cheapest	2nd Cheapest
126	1,432,770	1,347,233	673,457	2,209,020	92,617	1,403	(£ 5,431,492.)	(£ 4,877,290.)	(£ 5,340,252.)	3rd Most expensive	1st Cheapest	2nd Cheapest
127	1,604,851	1,572,557	754,342	2,569,532	108,107	1,638	(£ 6,102,497.)	(£ 5,455,928.)	(£ 6,062,084.)	3rd Most expensive	1st Cheapest	2nd Cheapest
128	1,771,254	1,795,796	832,558	2,926,451	123,454	1,871	(£ 6,773,503.)	(£ 6,034,567.)	(£ 6,735,892.)	3rd Most expensive	1st Cheapest	2nd Cheapest
129	1,937,658	2,019,035	910,774	3,283,369	138,801	2,103	(£ 7,444,508.)	(£ 6,613,205.)	(£ 7,409,700.)	3rd Most expensive	1st Cheapest	2nd Cheapest
130	2,104,061	2,242,274	988,990	3,640,287	154,148	2,336	(£ 8,115,514.)	(£ 7,191,844.)	(£ 8,083,508.)	3rd Most expensive	1st Cheapest	2nd Cheapest
131	2,270,465	2,465,513	1,067,206	3,997,205	169,495	2,568	(£ 8,850,302.)	(£ 7,770,482.)	(£ 8,757,316.)	3rd Most expensive	1st Cheapest	2nd Cheapest
132	2,436,868	2,688,752	1,145,422	4,354,123	184,842	2,801	(£ 9,532,563.)	(£ 8,349,121.)	(£ 9,431,124.)	3rd Most expensive	1st Cheapest	2nd Cheapest
133	2,603,272	2,911,991	1,223,639	4,711,042	200,189	3,033	(£ 10,214,824.)	(£ 8,927,759.)	(£ 10,104,932.)	3rd Most expensive	1st Cheapest	2nd Cheapest
134	2,777,481	3,138,096	1,305,524	5,072,902	215,732	3,269	(£ 10,963,119.)	(£ 9,572,431.)	(£ 10,844,774.)	3rd Most expensive	1st Cheapest	2nd Cheapest
135	2,944,949	3,361,725	1,384,240	5,430,494	231,106	3,502	(£ 11,654,385.)	(£ 10,160,074.)	(£ 11,527,586.)	3rd Most expensive	1st Cheapest	2nd Cheapest
136	3,112,417	3,585,355	1,462,957	5,788,087	246,480	3,735	(£ 12,345,650.)	(£ 10,807,747.)	(£ 12,210,399.)	3rd Most expensive	1st Cheapest	2nd Cheapest
137	3,287,266	3,811,695	1,545,142	6,150,351	262,040	3,970	(£ 13,099,348.)	(£ 11,465,326.)	(£ 12,955,643.)	3rd Most expensive	1st Cheapest	2nd Cheapest
138	3,455,586	4,035,637	1,624,259	6,508,483	277,435	4,204	(£ 13,797,817.)	(£ 12,067,676.)	(£ 13,645,659.)	3rd Most expensive	1st Cheapest	2nd Cheapest
139	3,623,905	4,259,580	1,703,376	6,866,614	292,830	4,437	(£ 14,496,287.)	(£ 12,670,027.)	(£ 14,335,675.)	3rd Most expensive	1st Cheapest	2nd Cheapest
140	3,792,225	4,483,522	1,782,493	7,224,745	308,226	4,670	(£ 15,194,756.)	(£ 13,272,377.)	(£ 15,025,691.)	3rd Most expensive	1st Cheapest	2nd Cheapest
141	3,960,544	4,707,465	1,861,609	7,582,877	323,621	4,903	(£ 15,893,225.)	(£ 13,874,728.)	(£ 15,715,708.)	3rd Most expensive	1st Cheapest	2nd Cheapest
142	4,128,864	4,931,407	1,940,726	7,941,008	339,016	5,137	(£ 16,591,695.)	(£ 14,477,078.)	(£ 16,405,724.)	3rd Most expensive	1st Cheapest	2nd Cheapest
143	4,297,184	5,155,350	2,019,843	8,299,139	354,411	5,370	(£ 17,290,164.)	(£ 15,079,429.)	(£ 17,095,740.)	3rd Most expensive	1st Cheapest	2nd Cheapest
144	4,465,503	5,379,292	2,098,960	8,657,271	369,806	5,603	(£ 17,988,634.)	(£ 15,681,779.)	(£ 17,785,756.)	3rd Most expensive	1st Cheapest	2nd Cheapest
145	4,633,823	5,603,234	2,178,076	9,015,402	385,202	5,836	(£ 18,687,103.)	(£ 16,284,130.)	(£ 18,475,772.)	3rd Most expensive	1st Cheapest	2nd Cheapest
146	4,802,142	5,827,177	2,257,193	9,373,533	400,597	6,070	(£ 19,385,573.)	(£ 16,886,480.)	(£ 19,165,789.)	3rd Most expensive	1st Cheapest	2nd Cheapest
147	4,970,462	6,051,119	2,336,310	9,731,665	415,992	6,303	(£ 20,084,042.)	(£ 17,488,831.)	(£ 19,855,805.)	3rd Most expensive	1st Cheapest	2nd Cheapest
148	5,138,781	6,275,062	2,415,426	10,089,796	431,387	6,536	(£ 20,782,511.)	(£ 18,091,181.)	(£ 20,545,821.)	3rd Most expensive	1st Cheapest	2nd Cheapest
149	5,307,101	6,499,004	2,494,543	10,447,927	446,783	6,769	(£ 21,480,981.)	(£ 18,693,532.)	(£ 21,235,837.)	3rd Most expensive	1st Cheapest	2nd Cheapest
150	5,475,421	6,722,947	2,573,660	10,806,059	462,178	7,003	(£ 22,179,450.)	(£ 19,295,882.)	(£ 21,925,853.)	3rd Most expensive	1st Cheapest	2nd Cheapest
151	875,345	585,444	411,446	1,013,747	40,247	610	(£ 2,664,462.)	(£ 2,418,150.)	(£ 3,004,748.)	2nd Cheapest	1st Cheapest	3rd Most expensive
152	1,303,567	1,158,397	612,727	1,951,896	79,636	1,207	(£ 3,923,466.)	(£ 3,430,842.)	(£ 4,604,037.)	2nd Cheapest	1st Cheapest	3rd Most expensive
153	1,741,724	1,734,999	818,678	2,896,335	119,275	1,807	(£ 5,182,469.)	(£ 4,443,533.)	(£ 6,287,368.)	2nd Cheapest	1st Cheapest	3rd Most expensive
154	2,175,623	2,310,037	1,022,627	3,838,079	158,807	2,406	(£ 6,501,503.)	(£ 5,456,225.)	(£ 7,934,682.)	2nd Cheapest	1st Cheapest	3rd Most expensive
155	2,616,618	2,887,681	1,229,912	4,784,315	198,517	3,008	(£ 7,850,553.)	(£ 6,528,947.)	(£ 9,642,026.)	2nd Cheapest	1st Cheapest	3rd Most expensive
156	3,053,356	3,463,761	1,435,196	5,727,856	238,121	3,608	(£ 9,163,584.)	(£ 7,625,681.)	(£ 11,313,351.)	2nd Cheapest	1st Cheapest	3rd Most expensive
157	3,498,894	4,043,073	1,644,616	6,676,968	277,946	4,211	(£ 10,551,052.)	(£ 8,756,832.)	(£ 13,059,114.)	2nd Cheapest	1st Cheapest	3rd Most expensive
158	3,937,902	4,619,987	1,850,967	7,621,946	317,607	4,812	(£ 11,883,293.)	(£ 9,832,756.)	(£ 14,749,650.)	2nd Cheapest	1st Cheapest	3rd Most expensive
159	4,376,911	5,196,901	2,057,318	8,566,925	357,268	5,413	(£ 13,215,534.)	(£ 10,908,679.)	(£ 16,440,185.)	2nd Cheapest	1st Cheapest	3rd Most expensive
160	4,815,920	5,773,816	2,263,669	9,511,903	396,929	6,014	(£ 14,547,774.)	(£ 11,984,603.)	(£ 18,130,720.)	2nd Cheapest	1st Cheapest	3rd Most expensive
161	5,254,928	6,350,730	2,470,020	10,456,882	436,589	6,615	(£ 15,880,015.)	(£ 13,060,526.)	(£ 19,821,256.)	2nd Cheapest	1st Cheapest	3rd Most expensive
162	5,693,937	6,927,644	2,676,371	11,401,860	476,250	7,216	(£ 17,212,256.)	(£ 14,136,450.)	(£ 21,511,791.)	2nd Cheapest	1st Cheapest	3rd Most expensive
163	6,132,946	7,504,558	2,882,722	12,346,839	515,911	7,817	(£ 18,544,496.)	(£ 15,212,373.)	(£ 23,202,326.)	2nd Cheapest	1st Cheapest	3rd Most expensive
164	6,571,954	8,081,473	3,089,073	13,291,817	555,571	8,418	(£ 19,876,737.)	(£ 16,288,297.)	(£ 24,892,861.)	2nd Cheapest	1st Cheapest	3rd Most expensive
165	7,010,963	8,658,387	3,295,424	14,236,796	595,232	9,019	(£ 21,208,978.)	(£ 17,364,221.)	(£ 26,583,397.)	2nd Cheapest	1st Cheapest	3rd Most expensive
166	1,039,619	807,901	488,661	1,369,317	55,540	842	(£ 3,335,468.)	(£ 2,996,789.)	(£ 3,660,547.)	2nd Cheapest	1st Cheapest	3rd Most expensive
167	1,640,632	1,606,439	771,160	2,668,428	110,437	1,673	(£ 5,265,477.)	(£ 4,588,119.)	(£ 5,987,671.)	2nd Cheapest	1st Cheapest	3rd Most expensive
168	2,240,934	2,404,716	1,053,326	3,967,090	165,315	2,505	(£ 7,259,268.)	(£ 6,179,449.)	(£ 8,308,792.)	2nd Cheapest	1st Cheapest	3rd Most expensive
169	2,849,753	3,206,120	1,339,494	5,271,143	220,409	3,340	(£ 9,302,585.)	(£ 7,842,815.)	(£ 10,701,950.)	2nd Cheapest	1st Cheapest	3rd Most expensive
170	3,462,474	4,008,957	1,627,497	6,577,668	275,601	4,176	(£ 11,378,918.)	(£ 9,616,738.)	(£ 13,128,125.)	2nd Cheapest	1st Cheapest	3rd Most expensive
171	4,069,803	4,809,813	1,912,965	7,880,778	330,657	5,010	(£ 13,409,628.)	(£ 11,295,012.)	(£ 15,508,676.)	2nd Cheapest	1st Cheapest	3rd Most expensive
172	4,677,131	5,610,670	2,198,433	9,183,887	385,713	5,844	(£ 15,440,338.)	(£ 12,973,286.)	(£ 17,889,228.)	2nd Cheapest	1st Cheapest	3rd Most expensive
173	5,284,459	6,411,527	2,483,901	10,486,997	440,769	6,678	(£ 17,471,048.)	(£ 14,651,560.)	(£ 20,269,779.)	2nd Cheapest	1st Cheapest	3rd Most expensive
174	5,891,787	7,212,384	2,769,368	11,790,107	495,825	7,512	(£ 19,501,758.)	(£ 16,329,834.)	(£ 22,650,331.)	2nd Cheapest	1st Cheapest	3rd Most expensive
175	6,499,115	8,013,240	3,054,836	13,093,217	550,881	8,347	(£ 21,532,469.)	(£ 18,008,108.)	(£ 25,030,882.)	2nd Cheapest	1st Cheapest	3rd Most expensive
176	7,106,444	8,814,097	3,340,304	14,396,326	605,937	9,181	(£ 23,563,179.)	(£ 19,686,382.)	(£ 27,411,434.)	2nd Cheapest	1st Cheapest	3rd Most expensive
177	7,713,772	9,614,954	3,625,772	15,699,436	660,993	10,015	(£ 25,593,889.)	(£ 21,364,656.)	(£ 29,791,985.)	2nd Cheapest	1st Cheapest	3rd Most expensive
178	8,321,100	10,415,810	3,911,240	17,002,546	716,049	10,849	(£ 27,624,599.)	(£ 23,042,930.)	(£ 32,172,537.)	2nd Cheapest	1st Cheapest	3rd Most expensive
179	8,928,428	11,216,667	4,196,707	18,305,656	771,104	11,683	(£ 29,655,309.)	(£ 24,721,204.)	(£ 34,553,088.)	2nd Cheapest	1st Cheapest	3rd Most expensive
180	9,535,757	12,017,524	4,482,175	19,608,765	826,160	12,518	(£ 31,686,019.)	(£ 26,399,478.)	(£ 36,933,640.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX H RESULTS WORKSHEET CONTINUED

			Graphed Results		Sensitivities															Fully Automated						Semi Automated						Manual						Result and Ranking: Graphed Results			Result and Ranking: Ranking Results		
		Test	Pax/Hour	Bags/Hour	# of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflation Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
High OPEX Factor	Short Haul Only	181	180	180	1	0	0%		0.59		1.1				3			2		1,971,621	817,652	926,738	794,235	31,911	484	1,925,196	801,518	904,917	782,573	31,368	475	1,898,551	729,572	892,393	803,873	30,113	456	(£ 5,247,884.)	(£ 5,044,417.)	(£ 5,147,116.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		182	360	360	2	0	0%		0.59		1.1				3			2		2,554,807	1,596,521	1,200,858	1,447,524	62,222	943	2,461,956	1,564,252	1,157,215	1,424,201	61,135	926	2,408,667	1,420,361	1,132,167	1,466,801	58,626	888	(£ 7,104,994.)	(£ 6,698,060.)	(£ 6,903,457.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		183	540	540	3	0	0%		0.59		1.1				3			2		3,137,993	2,375,389	1,474,978	2,100,814	92,532	1,402	2,998,716	2,326,986	1,409,513	2,065,829	90,902	1,377	2,918,782	2,111,149	1,371,941	2,129,729	87,139	1,320	(£ 8,962,104.)	(£ 8,351,703.)	(£ 8,659,799.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		184	720	720	4	0	0%		0.59		1.1				3			2		3,721,178	3,154,257	1,749,098	2,754,103	122,843	1,861	3,535,476	3,089,720	1,661,811	2,707,456	120,669	1,828	3,428,897	2,801,938	1,611,715	2,792,656	115,651	1,752	(£ 10,819,213.)	(£ 10,005,345.)	(£ 10,416,140.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		185	900	900	5	0	0%		0.59		1.1				3			2		4,304,364	3,933,125	2,023,218	3,407,392	153,153	2,321	4,072,236	3,852,454	1,914,109	3,349,084	150,436	2,279	3,939,013	3,492,726	1,851,489	3,455,584	144,164	2,184	(£ 12,676,323.)	(£ 11,658,988.)	(£ 12,172,481.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		186	1080	1080	6	0	0%		0.59		1.1				3			2		4,887,549	4,711,994	2,297,338	4,060,682	183,463	2,780	4,608,996	4,615,187	2,166,407	3,990,712	180,203	2,730	4,449,128	4,183,514	2,091,263	4,118,512	172,676	2,616	(£ 14,533,433.)	(£ 13,312,631.)	(£ 13,928,823.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		187	1260	1260	7	0	0%		0.59		1.1				3			2		5,470,735	5,490,862	2,571,457	4,713,971	213,774	3,239	5,145,756	5,377,921	2,418,705	4,632,339	209,970	3,181	4,983,484	4,883,203	2,342,431	4,790,654	201,556	3,054	(£ 16,390,542.)	(£ 14,966,274.)	(£ 15,824,774.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		188	1440	1440	8	0	0%		0.59		1.1				3			2		6,053,920	6,269,730	2,845,577	5,367,261	244,084	3,698	5,682,516	6,140,655	2,671,003	5,273,967	239,737	3,632	5,500,211	5,576,419	2,585,312	5,456,094	230,169	3,487	(£ 18,247,652.)	(£ 16,619,916.)	(£ 17,619,191.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		189	1620	1620	9	0	0%		0.59		1.1				3			2		6,637,106	7,048,599	3,119,697	6,020,550	274,395	4,157	6,219,276	6,903,389	2,923,301	5,915,595	269,504	4,083	6,016,937	6,269,634	2,828,194	6,121,535	258,782	3,921	(£ 20,104,761.)	(£ 18,273,559.)	(£ 19,413,608.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		190	1800	1800	10	0	0%		0.59		1.1				3			2		7,220,291	7,827,467	3,393,817	6,673,839	304,705	4,617	6,756,036	7,666,123	3,175,599	6,557,223	299,271	4,534	6,533,664	6,962,850	3,071,075	6,786,976	287,395	4,354	(£ 21,961,871.)	(£ 19,927,202.)	(£ 21,208,025.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		191	1980	1980	11	0	0%		0.59		1.1				3			2		7,826,892	8,614,932	3,678,942	7,336,029	335,370	5,081	7,292,796	8,428,857	3,427,897	7,198,850	329,038	4,985	7,050,390	7,656,066	3,313,957	7,452,417	316,007	4,788	(£ 23,953,832.)	(£ 21,580,844.)	(£ 23,002,442.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		192	2160	2160	12	0	0%		0.59		1.1				3			2		8,414,209	9,395,317	3,955,004	7,990,889	365,744	5,542	7,829,556	9,191,591	3,680,195	7,840,478	358,805	5,436	7,567,117	8,349,281	3,556,838	8,117,857	344,620	5,222	(£ 25,834,738.)	(£ 23,234,487.)	(£ 24,796,859.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		193	2340	2340	13	0	0%		0.59		1.1				3			2		9,001,527	10,175,703	4,231,066	8,645,749	396,117	6,002	8,366,316	9,954,325	3,932,493	8,482,106	388,572	5,887	8,083,843	9,042,497	3,799,720	8,783,298	373,233	5,655	(£ 27,715,645.)	(£ 24,888,130.)	(£ 26,591,276.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		194	2520	2520	14	0	0%		0.59		1.1				3			2		9,613,085	10,964,988	4,518,523	9,309,824	426,857	6,468	8,927,317	10,725,959	4,196,185	9,132,948	418,706	6,344	8,624,811	9,744,613	4,053,995	9,457,953	402,213	6,094	(£ 29,736,163.)	(£ 26,681,383.)	(£ 28,525,303.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		195	2700	2700	15	0	0%		0.59		1.1				3			2		10,203,708	11,746,587	4,796,138	9,965,940	457,280	6,928	9,467,383	11,489,906	4,450,037	9,775,832	448,523	6,796	9,144,843	10,439,042	4,298,431	10,124,651	430,876	6,528	(£ 31,636,107.)	(£ 28,354,063.)	(£ 30,338,757.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		196	2880	2880	16	0	0%		0.59		1.1				3			2		10,794,332	12,528,186	5,073,754	10,622,057	487,703	7,389	10,029,486	12,261,945	4,714,247	10,427,093	478,674	7,253	9,664,875	11,133,471	4,542,866	10,791,348	459,539	6,963	(£ 33,536,052.)	(£ 30,153,662.)	(£ 32,152,212.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		197	3060	3060	17	0	0%		0.59		1.1				3			2		11,407,873	13,318,200	5,362,143	11,286,885	518,474	7,856	10,595,225	13,035,318	4,980,167	11,079,736	508,880	7,710	10,207,826	11,836,315	4,798,074	11,466,757	488,549	7,402	(£ 35,567,992.)	(£ 31,974,203.)	(£ 34,097,662.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		198	3240	3240	18	0	0%		0.59		1.1				3			2		12,001,141	14,100,770	5,641,002	11,944,007	548,937	8,317	11,140,690	13,801,248	5,236,556	11,724,673	538,779	8,163	10,730,503	12,531,716	5,043,752	12,134,459	517,252	7,837	(£ 37,483,166.)	(£ 33,677,978.)	(£ 35,926,347.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		199	3420	3420	19	0	0%		0.59		1.1				3			2		12,594,409	14,883,339	5,919,860	12,601,129	579,400	8,779	11,686,155	14,567,178	5,492,946	12,369,609	568,678	8,616	11,253,179	13,227,116	5,289,430	12,802,162	545,955	8,272	(£ 39,398,341.)	(£ 35,381,754.)	(£ 37,755,032.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		200	3600	3600	20	0	0%		0.59		1.1				3			2		13,187,676	15,665,909	6,198,719	13,258,251	609,863	9,240	12,231,619	15,333,108	5,749,335	13,014,546	598,577	9,069	11,775,856	13,922,516	5,535,109	13,469,864	574,658	8,707	(£ 41,313,516.)	(£ 37,085,529.)	(£ 39,583,717.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		201	3780	3780	21	0	0%		0.59		1.1				3			2		13,780,944	16,448,479	6,477,578	13,915,372	640,327	9,702	12,777,084	16,099,038	6,005,725	13,659,483	628,476	9,522	12,298,532	14,617,917	5,780,787	14,137,567	603,361	9,142	(£ 43,228,691.)	(£ 38,789,305.)	(£ 41,412,401.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		202	3960	3960	22	0	0%		0.59		1.1				3			2		14,374,212	17,231,049	6,756,437	14,572,494	670,790	10,163	13,322,549	16,864,968	6,262,115	14,304,419	658,375	9,975	12,821,209	15,313,317	6,026,465	14,805,269	632,064	9,577	(£ 45,143,866.)	(£ 40,493,080.)	(£ 43,241,086.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		203	4140	4140	23	0	0%		0.59		1.1				3			2		14,967,479	18,013,619	7,035,295	15,229,616	701,253	10,625	13,868,014	17,630,897	6,518,504	14,949,356	688,274	10,428	13,343,886	16,008,717	6,272,144	15,472,972	660,767	10,012	(£ 47,059,041.)	(£ 42,196,856.)	(£ 45,069,771.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		204	4320	4320	24	0	0%		0.59		1.1				3			2		15,560,747	18,796,189	7,314,154	15,886,738	731,716	11,087	14,413,479	18,396,827	6,774,894	15,594,292	718,173	10,881	13,866,562	16,704,117	6,517,822	16,140,674	689,470	10,447	(£ 48,974,216.)	(£ 43,900,631.)	(£ 46,898,456.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		205	4500	4500	25	0	0%		0.59		1.1				3			2		16,154,014	19,578,759	7,593,013	16,543,860	762,180	11,548	14,958,943	19,162,757	7,031,283	16,239,229	748,072	11,334	14,389,239	17,399,518	6,763,500	16,808,377	718,173	10,881	(£ 50,889,390.)	(£ 45,604,407.)	(£ 48,727,141.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		206	4680	4680	26	0	0%		0.59		1.1				3			2		16,747,282	20,361,329	7,871,872	17,200,981	792,643	12,010	15,504,408	19,928,687	7,287,673	16,884,165	777,971	11,787	14,911,915	18,094,918	7,009,178	17,476,079	746,876	11,316	(£ 52,804,565.)	(£ 47,308,182.)	(£ 50,555,826.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		207	4860	4860	27	0	0%		0.59		1.1				3			2		17,340,550	21,143,899	8,150,731	17,858,103	823,106	12,471	16,049,873	20,694,617	7,544,062	17,529,102	807,870	12,240	15,434,592	18,790,318	7,254,857	18,143,782	775,579	11,751	(£ 54,719,740.)	(£ 49,011,958.)	(£ 52,384,511.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		208	5040	5040	28	0	0%		0.59		1.1				3			2		17,933,817	21,926,469	8,429,589	18,515,225	853,569	12,933	16,595,338	21,460,547	7,800,452	18,174,038	837,768	12,693	15,957,269	19,485,718	7,500,535	18,811,484	804,281	12,186	(£ 56,634,915.)	(£ 50,715,733.)	(£ 54,213,195.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		209	5220	5220	29	0	0%		0.59		1.1				3			2		18,527,085	22,709,039	8,708,448	19,172,347	884,032	13,394	17,140,802	22,226,476	8,056,842	18,818,975	867,667	13,146	16,479,945	20,181,119	7,746,213	19,479,186	832,984	12,621	(£ 58,550,090.)	(£ 52,419,509.)	(£ 56,041,880.)	3rd Most expensive	1st Cheapest	2nd Cheapest
		210	5400	5400	30	0	0%		0.59		1.1				3			2		19,120,352	23,491,609	8,987,307	19,829,468	914,496	13,856	17,686,267	22,992,406	8,313,231	19,463,912	897,566	13,599	17,002,622	20,876,519	7,991,891	20,146,889	861,687	13,056	(£ 60,465,265.)	(£ 54,123,284.)	(£ 57,870,565.)	3rd Most expensive	1st Cheapest	2nd Cheapest
	Long Haul Only	211	400	480	0	1	0%		0.59		1.1				3			2		2,863,121	1,524,942	1,345,778	1,847,092	60,492	917	2,739,320	1,481,917	1,287,587	1,815,994	59,043	895	2,718,177	1,817,956	1,277,648	1,890,037	75,037	1,137	(£ 7,091,610.)	(£ 6,549,031.)	(£ 7,755,652.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		212	800	960	0	2	0%		0.59		1.1				3			2		4,337,807	3,011,099	2,038,937	3,553,239	119,384	1,809	4,090,204	2,925,049	1,922,555	3,491,043	116,486	1,765	4,047,917	3,597,129	1,902,678	3,639,128	148,473	2,250	(£ 10,792,444.)	(£ 9,707,287.)	(£ 12,120,529.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		213	1200	1440	0	3	0%		0.59		1.1				3			2		5,812,493	4,497,256	2,732,097	5,259,385	178,275	2,701	5,441,089	4,368,181	2,557,523	5,166,092	173,928	2,635	5,408,510	5,387,628	2,542,209	5,399,947	222,377	3,369	(£ 14,493,279.)	(£ 12,865,544.)	(£ 16,663,093.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		214	1600	1920	0	4	0%		0.59		1.1				3			2		7,309,216	5,991,505	3,435,615	6,973,909	237,501	3,598	6,791,973	5,811,314	3,192,491	6,841,141	231,370	3,506	6,755,881	7,173,273	3,175,526	7,155,740	296,080	4,486	(£ 18,321,033.)	(£ 16,023,800.)	(£ 21,129,505.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		215	2000	2400	0	5	0%		0.59		1.1				3			2		8,816,957	7,489,799	4,144,312	8,692,621	296,893	4,498	8,164,894	7,262,537	3,837,817	8,524,567	289,147	4,381	8,125,288	8,967,009	3,819,201	8,919,910	370,117	5,608	(£ 22,212,245.)	(£ 19,308,975.)	(£ 25,722,836.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		216	2400	2880	0	6	0%		0.59		1.1				3			2		10,311,476	8,983,238	4,846,794	10,406,307	356,086	5,395	9,546,631	8,716,997	4,487,287	10,211,343	347,057	5,258	9,481,474	10,755,891	4,456,660	10,679,054	443,954	6,727	(£ 26,027,307.)	(£ 22,644,917.)	(£ 30,240,015.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		217	2800	3360	0	7	0%		0.59		1.1				3			2		11,833,322	10,486,711	5,562,120	12,130,380	415,692	6,298	10,941,002	10,176,096	5,142,695	11,902,922	405,158	6,139	10,864,986	12,554,805	5,106,964	12,448,584	518,205	7,852	(£ 29,999,747.)	(£ 26,053,626.)	(£ 34,914,574.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		218	3200	3840	0	8	0%		0.59		1.1				3			2		13,334,893	11,982,739	6,267,917	13,846,746	474,991	7,197	12,315,099	11,627,751	5,788,574	13,586,794	462,952	7,014	12,228,223	14,346,276	5,747,739	14,210,409	592,149	8,972	(£ 33,855,423.)	(£ 29,345,570.)	(£ 39,472,367.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		219	3600	4320	0	9	0%		0.59		1.1				3			2		14,836,464	13,478,768	6,973,713	15,563,112	534,290	8,095	13,689,196	13,079,406	6,434,453	15,270,667	520,746	7,890	13,591,460	16,137,747	6,388,513	15,972,233	666,092	10,092	(£ 37,711,098.)	(£ 32,637,514.)	(£ 44,030,161.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		220	4000	4800	0	10	0%		0.59		1.1				3			2		16,338,035	14,974,796	7,679,510	17,279,479	593,589	8,994	15,063,293	14,531,061	7,080,332	16,954,539	578,540	8,766	14,954,698	17,929,217	7,029,288	17,734,057	740,036	11,213	(£ 41,566,774.)	(£ 35,929,458.)	(£ 48,587,954.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		221	4400	5280	0	11	0%		0.59		1.1				3			2		17,839,606	16,470,825	8,385,307	18,995,845	652,888	9,892	16,437,390	15,982,716	7,726,210	18,638,412	636,334	9,641	16,317,935	19,720,688	7,670,062	19,495,881	813,980	12,333	(£ 45,422,449.)	(£ 39,221,402.)	(£ 53,145,748.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		222	4800	5760	0	12	0%		0.59		1.1				3			2		19,341,177	17,966,853	9,091,103	20,712,212	712,187	10,791	17,811,486	17,434,371	8,372,089	20,322,284	694,129	10,517	17,681,172	21,512,158	8,310,836	21,257,706	887,924	13,453	(£ 49,278,125.)	(£ 42,513,346.)	(£ 57,703,541.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		223	5200	6240	0	13	0%		0.59		1.1				3			2		20,842,749	19,462,881	9,796,900	22,428,578	771,486	11,689	19,185,583	18,886,026	9,017,968	22,006,157	751,923	11,393	19,044,410	23,303,629	8,951,611	23,019,530	961,867	14,574	(£ 53,133,800.)	(£ 45,805,289.)	(£ 62,261,335.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		224	5600	6720	0	14	0%		0.59		1.1				3			2		22,344,320	20,958,910	10,502,696	24,144,944	830,785	12,588	20,559,680	20,337,681	9,663,847	23,690,029	809,717	12,268	20,407,647	25,095,100	9,592,385	24,781,354	1,035,811	15,694	(£ 56,989,476.)	(£ 49,097,233.)	(£ 66,819,128.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		225	6000	7200	0	15	0%		0.59		1.1				3			2		23,845,891	22,454,938	11,208,493	25,861,311	890,084	13,486	21,933,777	21,789,336	10,309,726	25,373,901	867,511	13,144	21,770,885	26,886,570	10,233,160	26,543,178	1,109,755	16,814	(£ 60,845,151.)	(£ 52,389,177.)	(£ 71,376,922.)	2nd Cheapest	1st Cheapest	3rd Most expensive
	Short Haul and Long Haul Mix	226	580	660	1	1	0%		0.59		1.1				3			2		3,446,307	2,303,810	1,619,898	2,500,382	90,803	1,376	3,276,080	2,244,650	1,539,885	2,457,622	88,810	1,346	3,228,292	2,508,745	1,517,422	2,552,965	103,550	1,569	(£ 8,948,719.)	(£ 8,202,674.)	(£ 9,511,993.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		227	1160	1320	2	2	0%		0.59		1.1				3			2		5,504,178	4,568,836	2,587,177	4,859,818	180,005	2,727	5,163,724	4,450,517	2,427,151	4,774,299	176,020	2,667	5,094,593	4,988,415	2,394,656	4,975,036	205,899	3,120	(£ 14,506,664.)	(£ 13,014,573.)	(£ 15,785,514.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		228	1740	1980	3	3	0%		0.59		1.1				3			2		7,585,464	6,842,458	3,565,462	7,228,154	269,562	4,084	7,051,369	6,656,383	3,314,417	7,090,975	263,229	3,988	6,958,690	7,467,275	3,270,854	7,396,270	308,215	4,670	(£ 20,199,459.)	(£ 17,826,472.)	(£ 22,046,343.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		229	2320	2640	4	4	0%		0.59		1.1				3			2		9,684,931	9,122,756	4,552,293	9,603,401	359,394	5,445	8,965,458	8,871,959	4,214,113	9,417,704	350,839	5,316	8,849,231	9,955,845	4,159,482	9,827,555	410,932	6,226	(£ 25,996,962.)	(£ 22,790,673.)	(£ 28,459,475.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		230	2900	3300	5	5	0%		0.59		1.1				3			2		11,796,518	11,407,503	5,544,821	11,983,256	449,410	6,809	10,920,132	11,102,435	5,132,885	11,759,860	439,064	6,652	10,751,894	12,448,865	5,053,807	12,263,448	513,832	7,785	(£ 31,864,271.)	(£ 27,988,616.)	(£ 34,942,411.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		231	3480	3960	6	6	0%		0.59		1.1				3			2		13,891,356	13,686,102	6,529,476	14,356,744	539,172	8,169	12,839,694	13,320,020	6,035,154	14,088,669	526,757	7,981	12,637,808	14,935,736	5,940,260	14,692,975	616,479	9,341	(£ 37,635,121.)	(£ 32,984,335.)	(£ 41,328,889.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		232	4060	4620	7	7	0%		0.59		1.1				3			2		15,986,195	15,964,700	7,514,131	16,730,232	628,934	9,529	14,759,256	15,537,605	6,937,422	16,417,478	614,450	9,310	14,523,722	17,422,607	6,826,712	17,122,502	719,126	10,896	(£ 43,405,971.)	(£ 37,980,055.)	(£ 47,715,368.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		233	4640	5280	8	8	0%		0.59		1.1				3			2		18,081,034	18,243,298	8,498,787	19,103,720	718,697	10,889	16,678,817	17,755,190	7,839,691	18,746,287	702,143	10,639	16,409,636	19,909,478	7,713,165	19,552,028	821,772	12,451	(£ 49,176,822.)	(£ 42,975,774.)	(£ 54,101,846.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		234	5220	5940	9	9	0%		0.59		1.1				3			2		20,175,873	20,521,897	9,483,442	21,477,208	808,459	12,249	18,598,379	19,972,774	8,741,959	21,075,096	789,836	11,967	18,295,550	22,396,349	8,599,618	21,981,555	924,419	14,006	(£ 54,947,672.)	(£ 47,971,493.)	(£ 60,488,324.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		235	5800	6600	10	10	0%		0.59		1.1				3			2		22,270,711	22,800,495	10,468,098	23,850,697	898,221	13,609	20,517,940	22,190,359	9,644,227	23,403,905	877,529	13,296	20,181,464	24,883,220	9,486,070	24,411,082	1,027,066	15,562	(£ 60,718,522.)	(£ 52,967,213.)	(£ 66,874,803.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		236	6380	7260	11	11	0%		0.59		1.1				3			2		24,365,550	25,079,094	11,452,753	26,224,185	987,983	14,969	22,437,502	24,407,944	10,546,496	25,732,714	965,222	14,625	22,067,378	27,370,091	10,372,523	26,840,608	1,129,712	17,117	(£ 66,489,373.)	(£ 57,962,932.)	(£ 73,261,281.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		237	6960	7920	12	12	0%		0.59		1.1				3			2		26,460,389	27,357,692	12,437,408	28,597,673	1,077,745	16,329	24,357,064	26,625,529	11,448,764	28,061,523	1,052,916	15,953	23,953,292	29,856,961	11,258,976	29,270,135	1,232,359	18,672	(£ 72,260,223.)	(£ 62,958,651.)	(£ 79,647,760.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		238	7540	8580	13	13	0%		0.59		1.1				3			2		28,555,228	29,636,290	13,422,064	30,971,161	1,167,508	17,690	26,276,625	28,843,114	12,351,033	30,390,332	1,140,609	17,282	25,839,206	32,343,832	12,145,428	31,699,662	1,335,006	20,227	(£ 78,031,073.)	(£ 67,954,371.)	(£ 86,034,238.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		239	8120	9240	14	14	0%		0.59		1.1				3			2		30,650,066	31,914,889	14,406,719	33,344,649	1,257,270	19,050	28,196,187	31,060,698	13,253,301	32,719,141	1,228,302	18,611	27,725,120	34,830,703	13,031,881	34,129,188	1,437,652	21,783	(£ 83,801,923.)	(£ 72,950,090.)	(£ 92,420,716.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		240	8700	9900	15	15	0%		0.59		1.1				3			2		32,744,905	34,193,487	15,391,375	35,718,137	1,347,032	20,410	30,115,749	33,278,283	14,155,569	35,047,950	1,315,995	19,939	29,611,033	37,317,574	13,918,334	36,558,715	1,540,299	23,338	(£ 89,572,774.)	(£ 77,945,810.)	(£ 98,807,195.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX H RESULTS WORKSHEET CONTINUED

			Graphed Results		Sensitivities														Fully Automated						Semi Automated						Manual						Result and Ranking: Graphed Results			Result and Ranking: Ranking Results		
		Test	Pax/Hour	Bags/Hour	# of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflation Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
Low OPEX Factor	Short Haul Only	241	180	180	1	0	0%		0.59				0.19		3			2		1,971,621	817,652	926,738	137,186	5,512	84	1,925,196	801,518	904,917	135,172	5,418	82	1,898,551	729,572	892,393	138,851	5,201	79	(£ 3,756,191.)	(£ 3,656,336.)	(£ 3,588,864.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		242	360	360	2	0	0%		0.59				0.19		3			2		2,554,807	1,596,521	1,200,858	250,027	10,747	163	2,461,956	1,564,252	1,157,215	245,998	10,560	160	2,408,667	1,420,361	1,132,167	253,357	10,126	153	(£ 5,331,715.)	(£ 5,132,005.)	(£ 4,997,060.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		243	540	540	3	0	0%		0.59				0.19		3			2		3,137,993	2,375,389	1,474,978	362,868	15,983	242	2,998,716	2,326,986	1,409,513	356,825	15,701	238	2,918,782	2,111,149	1,371,941	367,862	15,051	228	(£ 6,907,239.)	(£ 6,607,674.)	(£ 6,405,256.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		244	720	720	4	0	0%		0.59				0.19		3			2		3,721,178	3,154,257	1,749,098	475,709	21,218	321	3,535,476	3,089,720	1,661,811	467,652	20,843	316	3,428,897	2,801,938	1,611,715	482,368	19,976	303	(£ 8,482,763.)	(£ 8,083,343.)	(£ 7,813,452.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		245	900	900	5	0	0%		0.59				0.19		3			2		4,304,364	3,933,125	2,023,218	588,550	26,454	401	4,072,236	3,852,454	1,914,109	578,478	25,984	394	3,939,013	3,492,726	1,851,489	596,874	24,901	377	(£ 10,058,286.)	(£ 9,559,011.)	(£ 9,221,649.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		246	1080	1080	6	0	0%		0.59				0.19		3			2		4,887,549	4,711,994	2,297,338	701,390	31,689	480	4,608,996	4,615,187	2,166,407	689,305	31,126	472	4,449,128	4,183,514	2,091,263	711,379	29,826	452	(£ 11,633,810.)	(£ 11,034,680.)	(£ 10,629,845.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		247	1260	1260	7	0	0%		0.59				0.19		3			2		5,470,735	5,490,862	2,571,457	814,231	36,925	559	5,145,756	5,377,921	2,418,705	800,131	36,268	550	4,983,484	4,883,203	2,342,431	827,477	34,814	527	(£ 13,209,334.)	(£ 12,510,349.)	(£ 12,096,309.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		248	1440	1440	8	0	0%		0.59				0.19		3			2		6,053,920	6,269,730	2,845,577	927,072	42,160	639	5,682,516	6,140,655	2,671,003	910,958	41,409	627	5,500,211	5,576,419	2,585,312	942,416	39,756	602	(£ 14,784,858.)	(£ 13,986,018.)	(£ 13,520,396.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		249	1620	1620	9	0	0%		0.59				0.19		3			2		6,637,106	7,048,599	3,119,697	1,039,913	47,395	718	6,219,276	6,903,389	2,923,301	1,021,785	46,551	705	6,016,937	6,269,634	2,828,194	1,057,356	44,699	677	(£ 16,360,381.)	(£ 15,461,686.)	(£ 14,944,484.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		250	1800	1800	10	0	0%		0.59				0.19		3			2		7,220,291	7,827,467	3,393,817	1,152,754	52,631	797	6,756,036	7,666,123	3,175,599	1,132,611	51,692	783	6,533,664	6,962,850	3,071,075	1,172,296	49,641	752	(£ 17,935,905.)	(£ 16,937,355.)	(£ 16,368,571.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		251	1980	1980	11	0	0%		0.59				0.19		3			2		7,826,892	8,614,932	3,678,942	1,267,132	57,928	878	7,292,796	8,428,857	3,427,897	1,243,438	56,834	861	7,050,390	7,656,066	3,313,957	1,287,236	54,583	827	(£ 19,567,710.)	(£ 18,413,024.)	(£ 17,792,659.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		252	2160	2160	12	0	0%		0.59				0.19		3			2		8,414,209	9,395,317	3,955,004	1,380,244	63,174	957	7,829,556	9,191,591	3,680,195	1,354,264	61,975	939	7,567,117	8,349,281	3,556,838	1,402,175	59,525	902	(£ 21,153,166.)	(£ 19,888,693.)	(£ 19,216,746.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		253	2340	2340	13	0	0%		0.59				0.19		3			2		9,001,527	10,175,703	4,231,066	1,493,357	68,420	1,037	8,366,316	9,954,325	3,932,493	1,465,091	67,117	1,017	8,083,843	9,042,497	3,799,720	1,517,115	64,468	977	(£ 22,738,622.)	(£ 21,364,361.)	(£ 20,640,833.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		254	2520	2520	14	0	0%		0.59				0.19		3			2		9,613,085	10,964,988	4,518,523	1,608,060	73,730	1,117	8,927,317	10,725,959	4,196,185	1,577,509	72,322	1,096	8,624,811	9,744,613	4,053,995	1,633,646	69,473	1,053	(£ 24,382,345.)	(£ 22,898,298.)	(£ 22,123,189.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		255	2700	2700	15	0	0%		0.59				0.19		3			2		10,203,708	11,746,587	4,796,138	1,721,390	78,985	1,197	9,467,383	11,489,906	4,450,037	1,688,553	77,472	1,174	9,144,843	10,439,042	4,298,431	1,748,803	74,424	1,128	(£ 25,975,747.)	(£ 24,381,912.)	(£ 23,555,222.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		256	2880	2880	16	0	0%		0.59				0.19		3			2		10,794,332	12,528,186	5,073,754	1,834,719	84,240	1,276	10,029,486	12,261,945	4,714,247	1,801,043	82,680	1,253	9,664,875	11,133,471	4,542,866	1,863,960	79,375	1,203	(£ 27,569,148.)	(£ 25,918,497.)	(£ 24,987,255.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		257	3060	3060	17	0	0%		0.59				0.19		3			2		11,407,873	13,318,200	5,362,143	1,949,553	89,555	1,357	10,595,225	13,035,318	4,980,167	1,913,773	87,898	1,332	10,207,826	11,836,315	4,798,074	1,980,622	84,386	1,279	(£ 29,217,639.)	(£ 27,463,823.)	(£ 26,474,377.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		258	3240	3240	18	0	0%		0.59				0.19		3			2		12,001,141	14,100,770	5,641,002	2,063,056	94,816	1,437	11,140,690	13,801,248	5,236,556	2,025,171	93,062	1,410	10,730,503	12,531,716	5,043,752	2,095,952	89,344	1,354	(£ 30,817,397.)	(£ 28,960,415.)	(£ 27,912,767.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		259	3420	3420	19	0	0%		0.59				0.19		3			2		12,594,409	14,883,339	5,919,860	2,176,559	100,078	1,516	11,686,155	14,567,178	5,492,946	2,136,569	98,226	1,488	11,253,179	13,227,116	5,289,430	2,211,283	94,301	1,429	(£ 32,417,155.)	(£ 30,457,007.)	(£ 29,351,157.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		260	3600	3600	20	0	0%		0.59				0.19		3			2		13,187,676	15,665,909	6,198,719	2,290,061	105,340	1,596	12,231,619	15,333,108	5,749,335	2,247,967	103,391	1,567	11,775,856	13,922,516	5,535,109	2,326,613	99,259	1,504	(£ 34,016,913.)	(£ 31,953,599.)	(£ 30,789,546.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		261	3780	3780	21	0	0%		0.59				0.19		3			2		13,780,944	16,448,479	6,477,578	2,403,564	110,602	1,676	12,777,084	16,099,038	6,005,725	2,359,365	108,555	1,645	12,298,532	14,617,917	5,780,787	2,441,943	104,217	1,579	(£ 35,616,670.)	(£ 33,450,192.)	(£ 32,227,936.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		262	3960	3960	22	0	0%		0.59				0.19		3			2		14,374,212	17,231,049	6,756,437	2,517,067	115,864	1,756	13,322,549	16,864,968	6,262,115	2,470,763	113,719	1,723	12,821,209	15,313,317	6,026,465	2,557,274	109,175	1,654	(£ 37,216,428.)	(£ 34,946,784.)	(£ 33,666,325.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		263	4140	4140	23	0	0%		0.59				0.19		3			2		14,967,479	18,013,619	7,035,295	2,630,570	121,126	1,835	13,868,014	17,630,897	6,518,504	2,582,161	118,884	1,801	13,343,886	16,008,717	6,272,144	2,672,604	114,132	1,729	(£ 38,816,186.)	(£ 36,443,376.)	(£ 35,104,715.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		264	4320	4320	24	0	0%		0.59				0.19		3			2		15,560,747	18,796,189	7,314,154	2,744,073	126,387	1,915	14,413,479	18,396,827	6,774,894	2,693,560	124,048	1,880	13,866,562	16,704,117	6,517,822	2,787,935	119,090	1,804	(£ 40,415,944.)	(£ 37,939,968.)	(£ 36,543,104.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		265	4500	4500	25	0	0%		0.59				0.19		3			2		16,154,014	19,578,759	7,593,013	2,857,576	131,649	1,995	14,958,943	19,162,757	7,031,283	2,804,958	129,212	1,958	14,389,239	17,399,518	6,763,500	2,903,265	124,048	1,880	(£ 42,015,702.)	(£ 39,436,560.)	(£ 37,981,494.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		266	4680	4680	26	0	0%		0.59				0.19		3			2		16,747,282	20,361,329	7,871,872	2,971,079	136,911	2,074	15,504,408	19,928,687	7,287,673	2,916,356	134,377	2,036	14,911,915	18,094,918	7,009,178	3,018,595	129,006	1,955	(£ 43,615,460.)	(£ 40,933,153.)	(£ 39,419,883.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		267	4860	4860	27	0	0%		0.59				0.19		3			2		17,340,550	21,143,899	8,150,731	3,084,581	142,173	2,154	16,049,873	20,694,617	7,544,062	3,027,754	139,541	2,114	15,434,592	18,790,318	7,254,857	3,133,926	133,964	2,030	(£ 45,215,218.)	(£ 42,429,745.)	(£ 40,858,273.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		268	5040	5040	28	0	0%		0.59				0.19		3			2		17,933,817	21,926,469	8,429,589	3,198,084	147,435	2,234	16,595,338	21,460,547	7,800,452	3,139,152	144,705	2,193	15,957,269	19,485,718	7,500,535	3,249,256	138,921	2,105	(£ 46,814,975.)	(£ 43,926,337.)	(£ 42,296,662.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		269	5220	5220	29	0	0%		0.59				0.19		3			2		18,527,085	22,709,039	8,708,448	3,311,587	152,697	2,314	17,140,802	22,226,476	8,056,842	3,250,550	149,870	2,271	16,479,945	20,181,119	7,746,213	3,364,587	143,879	2,180	(£ 48,414,733.)	(£ 45,422,929.)	(£ 43,735,052.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		270	5400	5400	30	0	0%		0.59				0.19		3			2		19,120,352	23,491,609	8,987,307	3,425,090	157,958	2,393	17,686,267	22,992,406	8,313,231	3,361,948	155,034	2,349	17,002,622	20,876,519	7,991,891	3,479,917	148,837	2,255	(£ 50,014,491.)	(£ 46,919,521.)	(£ 45,173,441.)	3rd Most expensive	2nd Cheapest	1st Cheapest
	Long Haul Only	271	400	480	0	1	0%		0.59				0.19		3			2		2,863,121	1,524,942	1,345,778	319,043	10,449	158	2,739,320	1,481,917	1,287,587	313,672	10,198	155	2,718,177	1,817,956	1,277,648	326,461	12,961	196	(£ 5,622,087.)	(£ 5,355,807.)	(£ 5,798,090.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		272	800	960	0	2	0%		0.59				0.19		3			2		4,337,807	3,011,099	2,038,937	613,741	20,621	312	4,090,204	2,925,049	1,922,555	602,998	20,120	305	4,047,917	3,597,129	1,902,678	628,577	25,645	389	(£ 9,063,507.)	(£ 8,530,947.)	(£ 9,415,513.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		273	1200	1440	0	3	0%		0.59				0.19		3			2		5,812,493	4,497,256	2,732,097	908,439	30,793	467	5,441,089	4,368,181	2,557,523	892,325	30,042	455	5,408,510	5,387,628	2,542,209	932,718	38,411	582	(£ 12,504,927.)	(£ 11,706,087.)	(£ 13,107,094.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		274	1600	1920	0	4	0%		0.59				0.19		3			2		7,309,216	5,991,505	3,435,615	1,204,584	41,023	622	6,791,973	5,811,314	3,192,491	1,181,652	39,964	606	6,755,881	7,173,273	3,175,526	1,235,992	51,141	775	(£ 15,999,317.)	(£ 14,881,227.)	(£ 16,766,893.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		275	2000	2400	0	5	0%		0.59				0.19		3			2		8,816,957	7,489,799	4,144,312	1,501,453	51,282	777	8,164,894	7,262,537	3,837,817	1,472,425	49,944	757	8,125,288	8,967,009	3,819,201	1,540,712	63,929	969	(£ 19,520,193.)	(£ 18,109,337.)	(£ 20,479,663.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		276	2400	2880	0	6	0%		0.59				0.19		3			2		10,311,476	8,983,238	4,846,794	1,797,453	61,506	932	9,546,631	8,716,997	4,487,287	1,763,777	59,946	908	9,481,474	10,755,891	4,456,660	1,844,564	76,683	1,162	(£ 23,009,286.)	(£ 21,358,636.)	(£ 24,160,651.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		277	2800	3360	0	7	0%		0.59				0.19		3			2		11,833,322	10,486,711	5,562,120	2,095,247	71,801	1,088	10,941,002	10,176,096	5,142,695	2,055,959	69,982	1,060	10,864,986	12,554,805	5,106,964	2,150,210	89,508	1,356	(£ 26,564,063.)	(£ 24,638,304.)	(£ 27,907,322.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		278	3200	3840	0	8	0%		0.59				0.19		3			2		13,334,893	11,982,739	6,267,917	2,391,711	82,044	1,243	12,315,099	11,627,751	5,788,574	2,346,810	79,964	1,212	12,228,223	14,346,276	5,747,739	2,454,525	102,280	1,550	(£ 30,070,107.)	(£ 27,869,240.)	(£ 31,605,260.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		279	3600	4320	0	9	0%		0.59				0.19		3			2		14,836,464	13,478,768	6,973,713	2,688,174	92,286	1,398	13,689,196	13,079,406	6,434,453	2,637,661	89,947	1,363	13,591,460	16,137,747	6,388,513	2,758,840	115,052	1,743	(£ 33,576,151.)	(£ 31,100,176.)	(£ 35,303,198.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		280	4000	4800	0	10	0%		0.59				0.19		3			2		16,338,035	14,974,796	7,679,510	2,984,637	102,529	1,553	15,063,293	14,531,061	7,080,332	2,928,511	99,930	1,514	14,954,698	17,929,217	7,029,288	3,063,155	127,824	1,937	(£ 37,082,195.)	(£ 34,331,111.)	(£ 39,001,136.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		281	4400	5280	0	11	0%		0.59				0.19		3			2		17,839,606	16,470,825	8,385,307	3,281,101	112,772	1,709	16,437,390	15,982,716	7,726,210	3,219,362	109,912	1,665	16,317,935	19,720,688	7,670,062	3,367,470	140,597	2,130	(£ 40,588,239.)	(£ 37,562,047.)	(£ 42,699,074.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		282	4800	5760	0	12	0%		0.59				0.19		3			2		19,341,177	17,966,853	9,091,103	3,577,564	123,014	1,864	17,811,486	17,434,371	8,372,089	3,510,213	119,895	1,817	17,681,172	21,512,158	8,310,836	3,671,786	153,369	2,324	(£ 44,094,283.)	(£ 40,792,982.)	(£ 46,397,012.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		283	5200	6240	0	13	0%		0.59				0.19		3			2		20,842,749	19,462,881	9,796,900	3,874,027	133,257	2,019	19,185,583	18,886,026	9,017,968	3,801,063	129,878	1,968	19,044,410	23,303,629	8,951,611	3,976,101	166,141	2,517	(£ 47,600,327.)	(£ 44,023,918.)	(£ 50,094,950.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		284	5600	6720	0	14	0%		0.59				0.19		3			2		22,344,320	20,958,910	10,502,696	4,170,490	143,499	2,174	20,559,680	20,337,681	9,663,847	4,091,914	139,860	2,119	20,407,647	25,095,100	9,592,385	4,280,416	178,913	2,711	(£ 51,106,372.)	(£ 47,254,853.)	(£ 53,792,888.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		285	6000	7200	0	15	0%		0.59				0.19		3			2		23,845,891	22,454,938	11,208,493	4,466,954	153,742	2,329	21,933,777	21,789,336	10,309,726	4,382,765	149,843	2,270	21,770,885	26,886,570	10,233,160	4,584,731	191,685	2,904	(£ 54,612,416.)	(£ 50,485,789.)	(£ 57,490,826.)	2nd Cheapest	1st Cheapest	3rd Most expensive
	Short Haul and Long Haul Mix	286	580	660	1	1	0%		0.59				0.19		3			2		3,446,307	2,303,810	1,619,898	431,884	15,684	238	3,276,080	2,244,650	1,539,885	424,498	15,340	232	3,228,292	2,508,745	1,517,422	440,967	17,886	271	(£ 7,197,611.)	(£ 6,831,476.)	(£ 7,206,286.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		287	1160	1320	2	2	0%		0.59				0.19		3			2		5,504,178	4,568,836	2,587,177	839,423	31,092	471	5,163,724	4,450,517	2,427,151	824,652	30,403	461	5,094,593	4,988,415	2,394,656	859,324	35,564	539	(£ 12,214,555.)	(£ 11,482,285.)	(£ 12,295,470.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		288	1740	1980	3	3	0%		0.59				0.19		3			2		7,585,464	6,842,458	3,565,462	1,248,499	46,561	705	7,051,369	6,656,383	3,314,417	1,224,805	45,467	689	6,958,690	7,467,275	3,270,854	1,277,537	53,237	807	(£ 17,287,779.)	(£ 16,133,093.)	(£ 17,379,357.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		289	2320	2640	4	4	0%		0.59				0.19		3			2		9,684,931	9,122,756	4,552,293	1,658,769	62,077	941	8,965,458	8,871,959	4,214,113	1,626,694	60,599	918	8,849,231	9,955,845	4,159,482	1,697,487	70,979	1,075	(£ 22,404,705.)	(£ 20,847,466.)	(£ 22,526,808.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		290	2900	3300	5	5	0%		0.59				0.19		3			2		11,796,518	11,407,503	5,544,821	2,069,835	77,625	1,176	10,920,132	11,102,435	5,132,885	2,031,249	75,838	1,149	10,751,894	12,448,865	5,053,807	2,118,232	88,753	1,345	(£ 27,550,765.)	(£ 25,659,394.)	(£ 27,703,393.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		291	3480	3960	6	6	0%		0.59				0.19		3			2		13,891,356	13,686,102	6,529,476	2,479,801	93,130	1,411	12,839,694	13,320,020	6,035,154	2,433,497	90,985	1,379	12,637,808	14,935,736	5,940,260	2,537,878	106,483	1,613	(£ 32,656,567.)	(£ 30,386,922.)	(£ 32,839,721.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		292	4060	4620	7	7	0%		0.59				0.19		3			2		15,986,195	15,964,700	7,514,131	2,889,767	108,634	1,646	14,759,256	15,537,605	6,937,422	2,835,746	106,132	1,608	14,523,722	17,422,607	6,826,712	2,957,523	124,213	1,882	(£ 37,762,368.)	(£ 35,114,450.)	(£ 37,976,048.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		293	4640	5280	8	8	0%		0.59				0.19		3			2		18,081,034	18,243,298	8,498,787	3,299,734	124,138	1,881	16,678,817	17,755,190	7,839,691	3,237,995	121,279	1,838	16,409,636	19,909,478	7,713,165	3,377,169	141,942	2,151	(£ 42,868,170.)	(£ 39,841,978.)	(£ 43,112,376.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		294	5220	5940	9	9	0%		0.59				0.19		3			2		20,175,873	20,521,897	9,483,442	3,709,700	139,643	2,116	18,598,379	19,972,774	8,741,959	3,640,244	136,426	2,067	18,295,550	22,396,349	8,599,618	3,796,814	159,672	2,419	(£ 47,973,972.)	(£ 44,569,505.)	(£ 48,248,704.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		295	5800	6600	10	10	0%		0.59				0.19		3			2		22,270,711	22,800,495	10,468,098	4,119,666	155,147	2,351	20,517,940	22,190,359	9,644,227	4,042,493	151,573	2,297	20,181,464	24,883,220	9,486,070	4,216,460	177,402	2,688	(£ 53,079,774.)	(£ 49,297,033.)	(£ 53,385,031.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		296	6380	7260	11	11	0%		0.59				0.19		3			2		24,365,550	25,079,094	11,452,753	4,529,632	170,652	2,586	22,437,502	24,407,944	10,546,496	4,444,741	166,720	2,526	22,067,378	27,370,091	10,372,523	4,636,105	195,132	2,957	(£ 58,185,576.)	(£ 54,024,561.)	(£ 58,521,359.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		297	6960	7920	12	12	0%		0.59				0.19		3			2		26,460,389	27,357,692	12,437,408	4,939,598	186,156	2,821	24,357,064	26,625,529	11,448,764	4,846,990	181,867	2,756	23,953,292	29,856,961	11,258,976	5,055,751	212,862	3,225	(£ 63,291,378.)	(£ 58,752,089.)	(£ 63,657,686.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		298	7540	8580	13	13	0%		0.59				0.19		3			2		28,555,228	29,636,290	13,422,064	5,349,564	201,660	3,055	26,276,625	28,843,114	12,351,033	5,249,239	197,014	2,985	25,839,206	32,343,832	12,145,428	5,475,396	230,592	3,494	(£ 68,397,180.)	(£ 63,479,616.)	(£ 68,794,014.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		299	8120	9240	14	14	0%		0.59				0.19		3			2		30,650,066	31,914,889	14,406,719	5,759,530	217,165	3,290	28,196,187	31,060,698	13,253,301	5,651,488	212,161	3,215	27,725,120	34,830,703	13,031,881	5,895,042	248,322	3,762	(£ 73,502,982.)	(£ 68,207,144.)	(£ 73,930,341.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		300	8700	9900	15	15	0%		0.59				0.19		3			2		32,744,905	34,193,487	15,391,375	6,169,496	232,669	3,525	30,115,749	33,278,283	14,155,569	6,053,737	227,308	3,444	29,611,033	37,317,574	13,918,334	6,314,687	266,052	4,031	(£ 78,608,783.)	(£ 72,934,672.)	(£ 79,066,669.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX H RESULTS WORKSHEET CONTINUED

High Inflation Rate

	Test	Graphed Results: Pax/Hour	Graphed Results: Bags/Hour	Sensitivities: # of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflation Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min
Short Haul Only	301	180	180	1	0	0%		0.59			0.59		7				2	
	302	360	360	2	0	0%		0.59			0.59		7				2	
	303	540	540	3	0	0%		0.59			0.59		7				2	
	304	720	720	4	0	0%		0.59			0.59		7				2	
	305	900	900	5	0	0%		0.59			0.59		7				2	
	306	1080	1080	6	0	0%		0.59			0.59		7				2	
	307	1260	1260	7	0	0%		0.59			0.59		7				2	
	308	1440	1440	8	0	0%		0.59			0.59		7				2	
	309	1620	1620	9	0	0%		0.59			0.59		7				2	
	310	1800	1800	10	0	0%		0.59			0.59		7				2	
	311	1980	1980	11	0	0%		0.59			0.59		7				2	
	312	2160	2160	12	0	0%		0.59			0.59		7				2	
	313	2340	2340	13	0	0%		0.59			0.59		7				2	
	314	2520	2520	14	0	0%		0.59			0.59		7				2	
	315	2700	2700	15	0	0%		0.59			0.59		7				2	
	316	2880	2880	16	0	0%		0.59			0.59		7				2	
	317	3060	3060	17	0	0%		0.59			0.59		7				2	
	318	3240	3240	18	0	0%		0.59			0.59		7				2	
	319	3420	3420	19	0	0%		0.59			0.59		7				2	
	320	3600	3600	20	0	0%		0.59			0.59		7				2	
	321	3780	3780	21	0	0%		0.59			0.59		7				2	
	322	3960	3960	22	0	0%		0.59			0.59		7				2	
	323	4140	4140	23	0	0%		0.59			0.59		7				2	
	324	4320	4320	24	0	0%		0.59			0.59		7				2	
	325	4500	4500	25	0	0%		0.59			0.59		7				2	
	326	4680	4680	26	0	0%		0.59			0.59		7				2	
	327	4860	4860	27	0	0%		0.59			0.59		7				2	
	328	5040	5040	28	0	0%		0.59			0.59		7				2	
	329	5220	5220	29	0	0%		0.59			0.59		7				2	
	330	5400	5400	30	0	0%		0.59			0.59		7				2	
Long Haul Only	331	400	480	0	1	0%		0.59			0.59		7				2	
	332	800	960	0	2	0%		0.59			0.59		7				2	
	333	1200	1440	0	3	0%		0.59			0.59		7				2	
	334	1600	1920	0	4	0%		0.59			0.59		7				2	
	335	2000	2400	0	5	0%		0.59			0.59		7				2	
	336	2400	2880	0	6	0%		0.59			0.59		7				2	
	337	2800	3360	0	7	0%		0.59			0.59		7				2	
	338	3200	3840	0	8	0%		0.59			0.59		7				2	
	339	3600	4320	0	9	0%		0.59			0.59		7				2	
	340	4000	4800	0	10	0%		0.59			0.59		7				2	
	341	4400	5280	0	11	0%		0.59			0.59		7				2	
	342	4800	5760	0	12	0%		0.59			0.59		7				2	
	343	5200	6240	0	13	0%		0.59			0.59		7				2	
	344	5600	6720	0	14	0%		0.59			0.59		7				2	
	345	6000	7200	0	15	0%		0.59			0.59		7				2	
Short Haul and Long Haul Mix	346	580	660	1	1	0%		0.59			0.59		7				2	
	347	1160	1320	2	2	0%		0.59			0.59		7				2	
	348	1740	1980	3	3	0%		0.59			0.59		7				2	
	349	2320	2640	4	4	0%		0.59			0.59		7				2	
	350	2900	3300	5	5	0%		0.59			0.59		7				2	
	351	3480	3960	6	6	0%		0.59			0.59		7				2	
	352	4060	4620	7	7	0%		0.59			0.59		7				2	
	353	4640	5280	8	8	0%		0.59			0.59		7				2	
	354	5220	5940	9	9	0%		0.59			0.59		7				2	
	355	5800	6600	10	10	0%		0.59			0.59		7				2	
	356	6380	7260	11	11	0%		0.59			0.59		7				2	
	357	6960	7920	12	12	0%		0.59			0.59		7				2	
	358	7540	8580	13	13	0%		0.59			0.59		7				2	
	359	8120	9240	14	14	0%		0.59			0.59		7				2	
	360	8700	9900	15	15	0%		0.59			0.59		7				2	

Test	Fully Automated: Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	Semi Automated: Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²
301	1,971,621	817,652	926,738	425,999	17,116	259	1,925,196	801,518	904,917	419,744	16,825	255
302	2,554,807	1,596,521	1,200,858	776,399	33,373	506	2,461,956	1,564,252	1,157,215	763,890	32,790	497
303	3,137,993	2,375,389	1,474,978	1,126,800	49,631	752	2,998,716	2,326,986	1,409,513	1,108,035	48,756	739
304	3,721,178	3,154,257	1,749,098	1,477,201	65,888	998	3,535,476	3,089,720	1,661,811	1,452,181	64,722	981
305	4,304,364	3,933,125	2,023,218	1,827,601	82,146	1,245	4,072,236	3,852,454	1,914,109	1,796,327	80,688	1,223
306	4,887,549	4,711,994	2,297,338	2,178,002	98,403	1,491	4,608,996	4,615,187	2,166,407	2,140,473	96,654	1,464
307	5,470,735	5,490,862	2,571,457	2,528,403	114,661	1,737	5,145,756	5,377,921	2,418,705	2,484,618	112,620	1,706
308	6,053,920	6,269,730	2,845,577	2,878,803	130,918	1,984	5,682,516	6,140,655	2,671,003	2,828,764	128,586	1,948
309	6,637,106	7,048,599	3,119,697	3,229,204	147,175	2,230	6,219,276	6,903,389	2,923,301	3,172,910	144,552	2,190
310	7,220,291	7,827,467	3,393,817	3,579,605	163,433	2,476	6,756,036	7,666,123	3,175,599	3,517,056	160,518	2,432
311	7,826,892	8,614,932	3,678,942	3,934,779	179,881	2,725	7,292,796	8,428,857	3,427,897	3,861,202	176,484	2,674
312	8,414,209	9,395,317	3,955,004	4,286,022	196,172	2,972	7,829,556	9,191,591	3,680,195	4,205,347	192,450	2,916
313	9,001,527	10,175,703	4,231,066	4,637,265	212,463	3,219	8,366,316	9,954,325	3,932,493	4,549,493	208,416	3,158
314	9,613,085	10,964,988	4,518,523	4,993,451	228,951	3,469	8,927,317	10,725,959	4,196,185	4,898,581	224,579	3,403
315	10,203,708	11,746,587	4,796,138	5,345,368	245,268	3,716	9,467,383	11,489,906	4,450,037	5,243,401	240,572	3,645
316	10,794,332	12,528,186	5,073,754	5,697,285	261,586	3,963	10,029,486	12,261,945	4,714,247	5,592,714	256,743	3,890
317	11,407,873	13,318,200	5,362,143	6,053,875	278,090	4,213	10,595,225	13,035,318	4,980,167	5,942,768	272,945	4,136
318	12,001,141	14,100,770	5,641,002	6,406,331	294,430	4,461	11,140,690	13,801,248	5,236,556	6,288,688	288,982	4,379
319	12,594,409	14,883,339	5,919,860	6,758,787	310,769	4,709	11,686,155	14,567,178	5,492,946	6,634,609	305,018	4,621
320	13,187,676	15,665,909	6,198,719	7,111,244	327,109	4,956	12,231,619	15,333,108	5,749,335	6,980,529	321,055	4,864
321	13,780,944	16,448,479	6,477,578	7,463,700	343,448	5,204	12,777,084	16,099,038	6,005,725	7,326,450	337,092	5,107
322	14,374,212	17,231,049	6,756,437	7,816,156	359,787	5,451	13,322,549	16,864,968	6,262,115	7,672,370	353,128	5,350
323	14,967,479	18,013,619	7,035,295	8,168,612	376,127	5,699	13,868,014	17,630,897	6,518,504	8,018,291	369,165	5,593
324	15,560,747	18,796,189	7,314,154	8,521,068	392,466	5,946	14,413,479	18,396,827	6,774,894	8,364,211	385,202	5,836
325	16,154,014	19,578,759	7,593,013	8,873,525	408,805	6,194	14,958,943	19,162,757	7,031,283	8,710,132	401,238	6,079
326	16,747,282	20,361,329	7,871,872	9,225,981	425,145	6,442	15,504,408	19,928,687	7,287,673	9,056,052	417,275	6,322
327	17,340,550	21,143,899	8,150,731	9,578,437	441,484	6,689	16,049,873	20,694,617	7,544,062	9,401,973	433,312	6,565
328	17,933,817	21,926,469	8,429,589	9,930,893	457,823	6,937	16,595,338	21,460,547	7,800,452	9,747,893	449,349	6,808
329	18,527,085	22,709,039	8,708,448	10,283,350	474,163	7,184	17,140,802	22,226,476	8,056,842	10,093,814	465,385	7,051
330	19,120,352	23,491,609	8,987,307	10,635,806	490,502	7,432	17,686,267	22,992,406	8,313,231	10,439,734	481,422	7,294
331	2,863,121	1,524,942	1,345,778	990,713	32,446	492	2,739,320	1,481,917	1,287,587	974,033	31,669	480
332	4,337,807	3,011,099	2,038,937	1,905,828	64,033	970	4,090,204	2,925,049	1,922,555	1,872,469	62,479	947
333	5,812,493	4,497,256	2,732,097	2,820,943	95,620	1,449	5,441,089	4,368,181	2,557,523	2,770,904	93,289	1,413
334	7,309,216	5,991,505	3,435,615	3,740,551	127,387	1,930	6,791,973	5,811,314	3,192,491	3,669,339	124,099	1,880
335	8,816,957	7,489,799	4,144,312	4,662,406	159,243	2,413	8,164,894	7,262,537	3,837,817	4,572,267	155,088	2,350
336	10,311,476	8,983,238	4,846,794	5,581,564	190,991	2,894	9,546,631	8,716,997	4,487,287	5,476,993	186,149	2,820
337	11,833,322	10,486,711	5,562,120	6,506,295	222,962	3,378	10,941,002	10,176,096	5,142,695	6,384,295	217,312	3,293
338	13,334,893	11,982,739	6,267,917	7,426,891	254,768	3,860	12,315,099	11,627,751	5,788,574	7,287,462	248,311	3,762
339	14,836,464	13,478,768	6,973,713	8,347,488	286,574	4,342	13,689,196	13,079,406	6,434,453	8,190,630	279,309	4,232
340	16,338,035	14,974,796	7,679,510	9,268,084	318,379	4,824	15,063,293	14,531,061	7,080,332	9,093,798	310,308	4,702
341	17,839,606	16,470,825	8,385,307	10,188,681	350,185	5,306	16,437,390	15,982,716	7,726,210	9,996,966	341,307	5,171
342	19,341,177	17,966,853	9,091,103	11,109,277	381,991	5,788	17,811,486	17,434,371	8,372,089	10,900,134	372,305	5,641
343	20,842,749	19,462,881	9,796,900	12,029,874	413,797	6,270	19,185,583	18,886,026	9,017,968	11,803,302	403,304	6,111
344	22,344,320	20,958,910	10,502,696	12,950,470	445,603	6,752	20,559,680	20,337,681	9,663,847	12,706,470	434,303	6,580
345	23,845,891	22,454,938	11,208,493	13,871,067	477,408	7,233	21,933,777	21,789,336	10,309,726	13,609,638	465,301	7,050
346	3,446,307	2,303,810	1,619,898	1,341,114	48,703	738	3,276,080	2,244,650	1,539,885	1,318,179	47,635	722
347	5,504,178	4,568,836	2,587,177	2,606,629	96,548	1,463	5,163,724	4,450,517	2,427,151	2,560,760	94,410	1,430
348	7,585,464	6,842,458	3,565,462	3,876,919	144,583	2,191	7,051,369	6,656,383	3,314,417	3,803,341	141,186	2,139
349	9,684,931	9,122,756	4,552,293	5,150,915	192,766	2,921	8,965,458	8,871,959	4,214,113	5,051,314	188,177	2,851
350	11,796,518	11,407,503	5,544,821	6,427,383	241,047	3,652	10,920,132	11,102,435	5,132,885	6,307,561	235,498	3,568
351	13,891,356	13,686,102	6,529,476	7,700,435	289,192	4,382	12,839,694	13,320,020	6,035,154	7,556,650	282,533	4,281
352	15,986,195	15,964,700	7,514,131	8,973,488	337,338	5,111	14,759,256	15,537,605	6,937,422	8,805,738	329,569	4,993
353	18,081,034	18,243,298	8,498,787	10,246,541	385,483	5,841	16,678,817	17,755,190	7,839,691	10,054,827	376,604	5,706
354	20,175,873	20,521,897	9,483,442	11,519,594	433,628	6,570	18,598,379	19,972,774	8,741,959	11,303,915	423,640	6,419
355	22,270,711	22,800,495	10,468,098	12,792,646	481,773	7,300	20,517,940	22,190,359	9,644,227	12,553,003	470,675	7,131
356	24,365,550	25,079,094	11,452,753	14,065,699	529,918	8,029	22,437,502	24,407,944	10,546,496	13,802,092	517,710	7,844
357	26,460,389	27,357,692	12,437,408	15,338,752	578,063	8,759	24,357,064	26,625,529	11,448,764	15,051,180	564,746	8,557
358	28,555,228	29,636,290	13,422,064	16,611,805	626,209	9,488	26,276,625	28,843,114	12,351,033	16,300,269	611,781	9,269
359	30,650,066	31,914,889	14,406,719	17,884,857	674,354	10,217	28,196,187	31,060,698	13,253,301	17,549,357	658,816	9,982
360	32,744,905	34,193,487	15,391,375	19,157,910	722,499	10,947	30,115,749	33,278,283	14,155,569	18,798,446	705,852	10,695

Test	Manual: Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	Result and Ranking — Graphed Results: WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	Ranking Results: WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
301	1,898,551	729,572	892,393	431,168	16,152	245	(£ 4,683,396.)	(£ 4,519,138.)	(£ 4,557,440.)	3rd Most expensive	1st Cheapest	2nd Cheapest
302	2,408,667	1,420,361	1,132,167	786,739	31,445	476	(£ 6,433,948.)	(£ 6,105,432.)	(£ 6,182,036.)	3rd Most expensive	1st Cheapest	2nd Cheapest
303	2,918,782	2,111,149	1,371,941	1,142,309	46,738	708	(£ 8,184,499.)	(£ 7,691,725.)	(£ 7,806,632.)	3rd Most expensive	1st Cheapest	2nd Cheapest
304	3,428,897	2,801,938	1,611,715	1,497,879	62,031	940	(£ 9,935,051.)	(£ 9,278,019.)	(£ 9,431,228.)	3rd Most expensive	1st Cheapest	2nd Cheapest
305	3,939,013	3,492,726	1,851,489	1,853,450	77,324	1,172	(£ 11,685,602.)	(£ 10,864,312.)	(£ 11,055,824.)	3rd Most expensive	1st Cheapest	2nd Cheapest
306	4,449,128	4,183,514	2,091,263	2,209,020	92,617	1,403	(£ 13,436,154.)	(£ 12,450,606.)	(£ 12,680,419.)	3rd Most expensive	1st Cheapest	2nd Cheapest
307	4,983,484	4,883,203	2,342,431	2,569,532	108,107	1,638	(£ 15,186,705.)	(£ 14,036,900.)	(£ 14,413,844.)	3rd Most expensive	1st Cheapest	2nd Cheapest
308	5,500,211	5,576,419	2,585,312	2,926,451	123,454	1,871	(£ 16,937,257.)	(£ 15,623,193.)	(£ 16,068,120.)	3rd Most expensive	1st Cheapest	2nd Cheapest
309	6,016,937	6,269,634	2,828,194	3,283,369	138,801	2,103	(£ 18,687,809.)	(£ 17,209,487.)	(£ 17,722,397.)	3rd Most expensive	1st Cheapest	2nd Cheapest
310	6,533,664	6,962,850	3,071,075	3,640,287	154,148	2,336	(£ 20,438,360.)	(£ 18,795,780.)	(£ 19,376,673.)	3rd Most expensive	1st Cheapest	2nd Cheapest
311	7,050,390	7,656,066	3,313,957	3,997,205	169,495	2,568	(£ 22,294,030.)	(£ 20,382,074.)	(£ 21,030,949.)	3rd Most expensive	1st Cheapest	2nd Cheapest
312	7,567,117	8,349,281	3,556,838	4,354,123	184,842	2,801	(£ 24,063,132.)	(£ 21,968,367.)	(£ 22,685,226.)	3rd Most expensive	1st Cheapest	2nd Cheapest
313	8,083,843	9,042,497	3,799,720	4,711,042	200,189	3,033	(£ 25,832,234.)	(£ 23,554,661.)	(£ 24,339,502.)	3rd Most expensive	1st Cheapest	2nd Cheapest
314	8,624,811	9,744,613	4,053,995	5,072,902	215,732	3,269	(£ 27,710,165.)	(£ 25,249,783.)	(£ 26,102,607.)	3rd Most expensive	1st Cheapest	2nd Cheapest
315	9,144,843	10,439,042	4,298,431	5,430,494	231,106	3,502	(£ 29,494,107.)	(£ 26,850,917.)	(£ 27,771,724.)	3rd Most expensive	1st Cheapest	2nd Cheapest
316	9,664,875	11,133,471	4,542,866	5,788,087	246,480	3,735	(£ 31,278,049.)	(£ 28,550,986.)	(£ 29,440,840.)	3rd Most expensive	1st Cheapest	2nd Cheapest
317	10,207,826	11,836,315	4,798,074	6,150,351	262,040	3,970	(£ 33,164,883.)	(£ 30,267,379.)	(£ 31,212,849.)	3rd Most expensive	1st Cheapest	2nd Cheapest
318	10,730,503	12,531,716	5,043,752	6,508,483	277,435	4,204	(£ 34,960,698.)	(£ 31,892,752.)	(£ 32,893,838.)	3rd Most expensive	1st Cheapest	2nd Cheapest
319	11,253,179	13,227,116	5,289,430	6,866,614	292,830	4,437	(£ 36,756,512.)	(£ 33,518,125.)	(£ 34,574,827.)	3rd Most expensive	1st Cheapest	2nd Cheapest
320	11,775,856	13,922,516	5,535,109	7,224,745	308,226	4,670	(£ 38,552,327.)	(£ 35,143,498.)	(£ 36,255,816.)	3rd Most expensive	1st Cheapest	2nd Cheapest
321	12,298,532	14,617,917	5,780,787	7,582,877	323,621	4,903	(£ 40,348,141.)	(£ 36,768,871.)	(£ 37,936,805.)	3rd Most expensive	1st Cheapest	2nd Cheapest
322	12,821,209	15,313,317	6,026,465	7,941,008	339,016	5,137	(£ 42,143,955.)	(£ 38,394,244.)	(£ 39,617,794.)	3rd Most expensive	1st Cheapest	2nd Cheapest
323	13,343,886	16,008,717	6,272,144	8,299,139	354,411	5,370	(£ 43,939,770.)	(£ 40,019,617.)	(£ 41,298,782.)	3rd Most expensive	1st Cheapest	2nd Cheapest
324	13,866,562	16,704,117	6,517,822	8,657,271	369,806	5,603	(£ 45,735,584.)	(£ 41,644,990.)	(£ 42,979,771.)	3rd Most expensive	1st Cheapest	2nd Cheapest
325	14,389,239	17,399,518	6,763,500	9,015,402	385,202	5,836	(£ 47,531,398.)	(£ 43,270,363.)	(£ 44,660,760.)	3rd Most expensive	1st Cheapest	2nd Cheapest
326	14,911,915	18,094,918	7,009,178	9,373,533	400,597	6,070	(£ 49,327,213.)	(£ 44,895,736.)	(£ 46,341,749.)	3rd Most expensive	1st Cheapest	2nd Cheapest
327	15,434,592	18,790,318	7,254,857	9,731,665	415,992	6,303	(£ 51,123,027.)	(£ 46,521,109.)	(£ 48,022,738.)	3rd Most expensive	1st Cheapest	2nd Cheapest
328	15,957,269	19,485,718	7,500,535	10,089,796	431,387	6,536	(£ 52,918,841.)	(£ 48,146,482.)	(£ 49,703,727.)	3rd Most expensive	1st Cheapest	2nd Cheapest
329	16,479,945	20,181,119	7,746,213	10,447,927	446,783	6,769	(£ 54,714,656.)	(£ 49,771,855.)	(£ 51,384,715.)	3rd Most expensive	1st Cheapest	2nd Cheapest
330	17,002,622	20,876,519	7,991,891	10,806,059	462,178	7,003	(£ 56,510,470.)	(£ 51,397,227.)	(£ 53,065,704.)	3rd Most expensive	1st Cheapest	2nd Cheapest
331	2,718,177	1,817,956	1,277,648	1,013,747	40,247	610	(£ 6,535,511.)	(£ 6,097,490.)	(£ 7,014,869.)	2nd Cheapest	1st Cheapest	3rd Most expensive
332	4,047,917	3,597,129	1,902,678	1,951,896	79,636	1,207	(£ 10,138,178.)	(£ 9,262,135.)	(£ 11,096,894.)	2nd Cheapest	1st Cheapest	3rd Most expensive
333	5,408,510	5,387,628	2,542,209	2,896,335	119,275	1,807	(£ 13,740,845.)	(£ 12,426,781.)	(£ 15,317,427.)	2nd Cheapest	1st Cheapest	3rd Most expensive
334	6,755,881	7,173,273	3,175,526	3,838,079	158,807	2,406	(£ 17,442,446.)	(£ 15,591,426.)	(£ 19,478,600.)	2nd Cheapest	1st Cheapest	3rd Most expensive
335	8,125,288	8,967,009	3,819,201	4,784,315	198,517	3,008	(£ 21,193,516.)	(£ 18,855,007.)	(£ 23,738,708.)	2nd Cheapest	1st Cheapest	3rd Most expensive
336	9,481,474	10,755,891	4,456,660	5,727,856	238,121	3,608	(£ 24,885,224.)	(£ 22,158,161.)	(£ 27,939,455.)	2nd Cheapest	1st Cheapest	3rd Most expensive
337	10,864,986	12,554,805	5,106,964	6,676,968	277,946	4,211	(£ 28,699,612.)	(£ 25,518,038.)	(£ 32,262,881.)	2nd Cheapest	1st Cheapest	3rd Most expensive
338	12,228,223	14,346,276	5,747,739	7,621,946	317,607	4,812	(£ 32,422,979.)	(£ 28,786,895.)	(£ 36,495,287.)	2nd Cheapest	1st Cheapest	3rd Most expensive
339	13,591,460	16,137,747	6,388,513	8,566,925	357,268	5,413	(£ 36,146,347.)	(£ 32,055,752.)	(£ 40,727,693.)	2nd Cheapest	1st Cheapest	3rd Most expensive
340	14,954,698	17,929,217	7,029,288	9,511,903	396,929	6,014	(£ 39,869,714.)	(£ 35,324,610.)	(£ 44,960,099.)	2nd Cheapest	1st Cheapest	3rd Most expensive
341	16,317,935	19,720,688	7,670,062	10,456,882	436,589	6,615	(£ 43,593,082.)	(£ 38,593,467.)	(£ 49,192,505.)	2nd Cheapest	1st Cheapest	3rd Most expensive
342	17,681,172	21,512,158	8,310,836	11,401,860	476,250	7,216	(£ 47,316,449.)	(£ 41,862,324.)	(£ 53,424,911.)	2nd Cheapest	1st Cheapest	3rd Most expensive
343	19,044,410	23,303,629	8,951,611	12,346,839	515,911	7,817	(£ 51,039,817.)	(£ 45,131,181.)	(£ 57,657,317.)	2nd Cheapest	1st Cheapest	3rd Most expensive
344	20,407,647	25,095,100	9,592,385	13,291,817	555,571	8,418	(£ 54,763,184.)	(£ 48,400,038.)	(£ 61,889,723.)	2nd Cheapest	1st Cheapest	3rd Most expensive
345	21,770,885	26,886,570	10,233,160	14,236,796	595,232	9,019	(£ 58,486,552.)	(£ 51,668,895.)	(£ 66,122,128.)	2nd Cheapest	1st Cheapest	3rd Most expensive
346	3,228,292	2,508,745	1,517,422	1,369,317	55,540	842	(£ 8,286,063.)	(£ 7,683,783.)	(£ 8,639,465.)	2nd Cheapest	1st Cheapest	3rd Most expensive
347	5,094,593	4,988,415	2,394,656	2,668,428	110,437	1,673	(£ 13,639,281.)	(£ 12,434,722.)	(£ 14,464,808.)	2nd Cheapest	1st Cheapest	3rd Most expensive
348	6,958,690	7,467,275	3,270,854	3,967,090	165,315	2,505	(£ 19,097,618.)	(£ 17,185,661.)	(£ 20,280,257.)	2nd Cheapest	1st Cheapest	3rd Most expensive
349	8,849,231	9,955,845	4,159,482	5,271,143	220,409	3,340	(£ 24,637,576.)	(£ 22,055,323.)	(£ 26,214,428.)	2nd Cheapest	1st Cheapest	3rd Most expensive
350	10,751,894	12,448,865	5,053,807	6,577,668	275,601	4,176	(£ 30,231,949.)	(£ 27,107,189.)	(£ 32,203,013.)	2nd Cheapest	1st Cheapest	3rd Most expensive
351	12,637,808	14,935,736	5,940,260	7,880,778	330,657	5,010	(£ 35,751,130.)	(£ 32,001,419.)	(£ 38,116,408.)	2nd Cheapest	1st Cheapest	3rd Most expensive
352	14,523,722	17,422,607	6,826,712	9,183,887	385,713	5,844	(£ 41,270,312.)	(£ 36,895,649.)	(£ 44,029,803.)	2nd Cheapest	1st Cheapest	3rd Most expensive
353	16,409,636	19,909,478	7,713,165	10,486,997	440,769	6,678	(£ 46,789,494.)	(£ 41,789,879.)	(£ 49,943,197.)	2nd Cheapest	1st Cheapest	3rd Most expensive
354	18,295,550	22,396,349	8,599,618	11,790,107	495,825	7,512	(£ 52,308,676.)	(£ 46,684,109.)	(£ 55,856,592.)	2nd Cheapest	1st Cheapest	3rd Most expensive
355	20,181,464	24,883,220	9,486,070	13,093,217	550,881	8,347	(£ 57,827,858.)	(£ 51,578,339.)	(£ 61,769,987.)	2nd Cheapest	1st Cheapest	3rd Most expensive
356	22,067,378	27,370,091	10,372,523	14,396,326	605,937	9,181	(£ 63,347,040.)	(£ 56,472,569.)	(£ 67,683,382.)	2nd Cheapest	1st Cheapest	3rd Most expensive
357	23,953,292	29,856,961	11,258,976	15,699,436	660,993	10,015	(£ 68,866,222.)	(£ 61,366,799.)	(£ 73,596,777.)	2nd Cheapest	1st Cheapest	3rd Most expensive
358	25,839,206	32,343,832	12,145,428	17,002,546	716,049	10,849	(£ 74,385,403.)	(£ 66,261,029.)	(£ 79,510,171.)	2nd Cheapest	1st Cheapest	3rd Most expensive
359	27,725,120	34,830,703	13,031,881	18,305,656	771,104	11,683	(£ 79,904,585.)	(£ 71,155,259.)	(£ 85,423,566.)	2nd Cheapest	1st Cheapest	3rd Most expensive
360	29,611,033	37,317,574	13,918,334	19,608,765	826,160	12,518	(£ 85,423,767.)	(£ 76,049,489.)	(£ 91,336,961.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX H RESULTS WORKSHEET CONTINUED

			Graphed Results		Sensitivities														
		Test	Pax/Hour	Bags/Hour	# of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflatin Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min
Low Inflation Rate	Short Haul Only	361	180	180	1	0	0%		0.59			0.59				1		2	
		362	360	360	2	0	0%		0.59			0.59				1		2	
		363	540	540	3	0	0%		0.59			0.59				1		2	
		364	720	720	4	0	0%		0.59			0.59				1		2	
		365	900	900	5	0	0%		0.59			0.59				1		2	
		366	1080	1080	6	0	0%		0.59			0.59				1		2	
		367	1260	1260	7	0	0%		0.59			0.59				1		2	
		368	1440	1440	8	0	0%		0.59			0.59				1		2	
		369	1620	1620	9	0	0%		0.59			0.59				1		2	
		370	1800	1800	10	0	0%		0.59			0.59				1		2	
		371	1980	1980	11	0	0%		0.59			0.59				1		2	
		372	2160	2160	12	0	0%		0.59			0.59				1		2	
		373	2340	2340	13	0	0%		0.59			0.59				1		2	
		374	2520	2520	14	0	0%		0.59			0.59				1		2	
		375	2700	2700	15	0	0%		0.59			0.59				1		2	
		376	2880	2880	16	0	0%		0.59			0.59				1		2	
		377	3060	3060	17	0	0%		0.59			0.59				1		2	
		378	3240	3240	18	0	0%		0.59			0.59				1		2	
		379	3420	3420	19	0	0%		0.59			0.59				1		2	
		380	3600	3600	20	0	0%		0.59			0.59				1		2	
		381	3780	3780	21	0	0%		0.59			0.59				1		2	
		382	3960	3960	22	0	0%		0.59			0.59				1		2	
		383	4140	4140	23	0	0%		0.59			0.59				1		2	
		384	4320	4320	24	0	0%		0.59			0.59				1		2	
		385	4500	4500	25	0	0%		0.59			0.59				1		2	
		386	4680	4680	26	0	0%		0.59			0.59				1		2	
		387	4860	4860	27	0	0%		0.59			0.59				1		2	
		388	5040	5040	28	0	0%		0.59			0.59				1		2	
		389	5220	5220	29	0	0%		0.59			0.59				1		2	
		390	5400	5400	30	0	0%		0.59			0.59				1		2	
	Long Haul Only	391	400	480	0	1	0%		0.59			0.59				1		2	
		392	800	960	0	2	0%		0.59			0.59				1		2	
		393	1200	1440	0	3	0%		0.59			0.59				1		2	
		394	1600	1920	0	4	0%		0.59			0.59				1		2	
		395	2000	2400	0	5	0%		0.59			0.59				1		2	
		396	2400	2880	0	6	0%		0.59			0.59				1		2	
		397	2800	3360	0	7	0%		0.59			0.59				1		2	
		398	3200	3840	0	8	0%		0.59			0.59				1		2	
		399	3600	4320	0	9	0%		0.59			0.59				1		2	
		400	4000	4800	0	10	0%		0.59			0.59				1		2	
		401	4400	5280	0	11	0%		0.59			0.59				1		2	
		402	4800	5760	0	12	0%		0.59			0.59				1		2	
		403	5200	6240	0	13	0%		0.59			0.59				1		2	
		404	5600	6720	0	14	0%		0.59			0.59				1		2	
		405	6000	7200	0	15	0%		0.59			0.59				1		2	
	Short Haul and Long Haul Mix	406	580	660	1	1	0%		0.59			0.59				1		2	
		407	1160	1320	2	2	0%		0.59			0.59				1		2	
		408	1740	1980	3	3	0%		0.59			0.59				1		2	
		409	2320	2640	4	4	0%		0.59			0.59				1		2	
		410	2900	3300	5	5	0%		0.59			0.59				1		2	
		411	3480	3960	6	6	0%		0.59			0.59				1		2	
		412	4060	4620	7	7	0%		0.59			0.59				1		2	
		413	4640	5280	8	8	0%		0.59			0.59				1		2	
		414	5220	5940	9	9	0%		0.59			0.59				1		2	
		415	5800	6600	10	10	0%		0.59			0.59				1		2	
		416	6380	7260	11	11	0%		0.59			0.59				1		2	
		417	6960	7920	12	12	0%		0.59			0.59				1		2	
		418	7540	8580	13	13	0%		0.59			0.59				1		2	
		419	8120	9240	14	14	0%		0.59			0.59				1		2	
		420	8700	9900	15	15	0%		0.59			0.59				1		2	

	Fully Automated						Semi Automated					
Test	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2
361	1,971,621	817,652	926,738	425,999	17,116	259	1,925,196	801,518	904,917	419,744	16,825	255
362	2,554,807	1,596,521	1,200,858	776,399	33,373	506	2,461,956	1,564,252	1,157,215	763,890	32,790	497
363	3,137,993	2,375,389	1,474,978	1,126,800	49,631	752	2,998,716	2,326,986	1,409,513	1,108,035	48,756	739
364	3,721,178	3,154,257	1,749,098	1,477,201	65,888	998	3,535,476	3,089,720	1,661,811	1,452,181	64,722	981
365	4,304,364	3,933,125	2,023,218	1,827,601	82,146	1,245	4,072,236	3,852,454	1,914,109	1,796,327	80,688	1,223
366	4,887,549	4,711,994	2,297,338	2,178,002	98,403	1,491	4,608,996	4,615,187	2,166,407	2,140,473	96,654	1,464
367	5,470,735	5,490,862	2,571,457	2,528,403	114,661	1,737	5,145,756	5,377,921	2,418,705	2,484,618	112,620	1,706
368	6,053,920	6,269,730	2,845,577	2,878,803	130,918	1,984	5,682,516	6,140,655	2,671,003	2,828,764	128,586	1,948
369	6,637,106	7,048,599	3,119,697	3,229,204	147,175	2,230	6,219,276	6,903,389	2,923,301	3,172,910	144,552	2,190
370	7,220,291	7,827,467	3,393,817	3,579,605	163,433	2,476	6,756,036	7,666,123	3,175,599	3,517,056	160,518	2,432
371	7,826,892	8,614,932	3,678,942	3,934,779	179,881	2,725	7,292,796	8,428,857	3,427,897	3,861,202	176,484	2,674
372	8,414,209	9,395,317	3,955,004	4,286,022	196,172	2,972	7,829,556	9,191,591	3,680,195	4,205,347	192,450	2,916
373	9,001,527	10,175,703	4,231,066	4,637,265	212,463	3,219	8,366,316	9,954,325	3,932,493	4,549,493	208,416	3,158
374	9,613,085	10,964,988	4,518,523	4,993,451	228,951	3,469	8,927,317	10,725,959	4,196,185	4,898,581	224,579	3,403
375	10,203,708	11,746,587	4,796,138	5,345,368	245,268	3,716	9,467,383	11,489,906	4,450,037	5,243,401	240,572	3,645
376	10,794,332	12,528,186	5,073,754	5,697,285	261,586	3,963	10,029,486	12,261,945	4,714,247	5,592,714	256,743	3,890
377	11,407,873	13,318,200	5,362,143	6,053,875	278,090	4,213	10,595,225	13,035,318	4,980,167	5,942,768	272,945	4,136
378	12,001,141	14,100,770	5,641,002	6,406,331	294,430	4,461	11,140,690	13,801,248	5,236,556	6,288,688	288,982	4,379
379	12,594,409	14,883,339	5,919,860	6,758,787	310,769	4,709	11,686,155	14,567,178	5,492,946	6,634,609	305,018	4,621
380	13,187,676	15,665,909	6,198,719	7,111,244	327,109	4,956	12,231,619	15,333,108	5,749,335	6,980,529	321,055	4,864
381	13,780,944	16,448,479	6,477,578	7,463,700	343,448	5,204	12,777,084	16,099,038	6,005,725	7,326,450	337,092	5,107
382	14,374,212	17,231,049	6,756,437	7,816,156	359,787	5,451	13,322,549	16,864,968	6,262,115	7,672,370	353,128	5,350
383	14,967,479	18,013,619	7,035,295	8,168,612	376,127	5,699	13,868,014	17,630,897	6,518,504	8,018,291	369,165	5,593
384	15,560,747	18,796,189	7,314,154	8,521,068	392,466	5,946	14,413,479	18,396,827	6,774,894	8,364,211	385,202	5,836
385	16,154,014	19,578,759	7,593,013	8,873,525	408,805	6,194	14,958,943	19,162,757	7,031,283	8,710,132	401,238	6,079
386	16,747,282	20,361,329	7,871,872	9,225,981	425,145	6,442	15,504,408	19,928,687	7,287,673	9,056,052	417,275	6,322
387	17,340,550	21,143,899	8,150,731	9,578,437	441,484	6,689	16,049,873	20,694,617	7,544,062	9,401,973	433,312	6,565
388	17,933,817	21,926,469	8,429,589	9,930,893	457,823	6,937	16,595,338	21,460,547	7,800,452	9,747,893	449,349	6,808
389	18,527,085	22,709,039	8,708,448	10,283,350	474,163	7,184	17,140,802	22,226,476	8,056,842	10,093,814	465,385	7,051
390	19,120,352	23,491,609	8,987,307	10,635,806	490,502	7,432	17,686,267	22,992,406	8,313,231	10,439,734	481,422	7,294
391	2,863,121	1,524,942	1,345,778	990,713	32,446	492	2,739,320	1,481,917	1,287,587	974,033	31,669	480
392	4,337,807	3,011,099	2,038,937	1,905,828	64,033	970	4,090,204	2,925,049	1,922,555	1,872,469	62,479	947
393	5,812,493	4,497,256	2,732,097	2,820,943	95,620	1,449	5,441,089	4,368,181	2,557,523	2,770,904	93,289	1,413
394	7,309,216	5,991,505	3,435,615	3,740,551	127,387	1,930	6,791,973	5,811,314	3,192,491	3,669,339	124,099	1,880
395	8,816,957	7,489,799	4,144,312	4,662,406	159,243	2,413	8,164,894	7,262,537	3,837,817	4,572,267	155,088	2,350
396	10,311,476	8,983,238	4,846,794	5,581,564	190,991	2,894	9,546,631	8,716,997	4,487,287	5,476,993	186,149	2,820
397	11,833,322	10,486,711	5,562,120	6,506,295	222,962	3,378	10,941,002	10,176,096	5,142,695	6,384,295	217,312	3,293
398	13,334,893	11,982,739	6,267,917	7,426,891	254,768	3,860	12,315,099	11,627,751	5,788,574	7,287,462	248,311	3,762
399	14,836,464	13,478,768	6,973,713	8,347,488	286,574	4,342	13,689,196	13,079,406	6,434,453	8,190,630	279,309	4,232
400	16,338,035	14,974,796	7,679,510	9,268,084	318,379	4,824	15,063,293	14,531,061	7,080,332	9,093,798	310,308	4,702
401	17,839,606	16,470,825	8,385,307	10,188,681	350,185	5,306	16,437,390	15,982,716	7,726,210	9,996,966	341,307	5,171
402	19,341,177	17,966,853	9,091,103	11,109,277	381,991	5,788	17,811,486	17,434,371	8,372,089	10,900,134	372,305	5,641
403	20,842,749	19,462,881	9,796,900	12,029,874	413,797	6,270	19,185,583	18,886,026	9,017,968	11,803,302	403,304	6,111
404	22,344,320	20,958,910	10,502,696	12,950,470	445,603	6,752	20,559,680	20,337,681	9,663,847	12,706,470	434,303	6,580
405	23,845,891	22,454,938	11,208,493	13,871,067	477,408	7,233	21,933,777	21,789,336	10,309,726	13,609,638	465,301	7,050
406	3,446,307	2,303,810	1,619,898	1,341,114	48,703	738	3,276,080	2,244,650	1,539,885	1,318,179	47,635	722
407	5,504,178	4,568,836	2,587,177	2,606,629	96,548	1,463	5,163,724	4,450,517	2,427,151	2,560,760	94,410	1,430
408	7,585,464	6,842,458	3,565,462	3,876,919	144,583	2,191	7,051,369	6,656,383	3,314,417	3,803,341	141,186	2,139
409	9,684,931	9,122,756	4,552,293	5,150,915	192,766	2,921	8,965,458	8,871,959	4,214,113	5,051,314	188,177	2,851
410	11,796,518	11,407,503	5,544,821	6,427,383	241,047	3,652	10,920,132	11,102,435	5,132,885	6,307,561	235,498	3,568
411	13,891,356	13,686,102	6,529,476	7,700,435	289,192	4,382	12,839,694	13,320,020	6,035,154	7,556,650	282,533	4,281
412	15,986,195	15,964,700	7,514,131	8,973,488	337,338	5,111	14,759,256	15,537,605	6,937,422	8,805,738	329,569	4,993
413	18,081,034	18,243,298	8,498,787	10,246,541	385,483	5,841	16,678,817	17,755,190	7,839,691	10,054,827	376,604	5,706
414	20,175,873	20,521,897	9,483,442	11,519,594	433,628	6,570	18,598,379	19,972,774	8,741,959	11,303,915	423,640	6,419
415	22,270,711	22,800,495	10,468,098	12,792,646	481,773	7,300	20,517,940	22,190,359	9,644,227	12,553,003	470,675	7,131
416	24,365,550	25,079,094	11,452,753	14,065,699	529,918	8,029	22,437,502	24,407,944	10,546,496	13,802,092	517,710	7,844
417	26,460,389	27,357,692	12,437,408	15,338,752	578,063	8,759	24,357,064	26,625,529	11,448,764	15,051,180	564,746	8,557
418	28,555,228	29,636,290	13,422,064	16,611,805	626,209	9,488	26,276,625	28,843,114	12,351,033	16,300,269	611,781	9,269
419	30,650,066	31,914,889	14,406,719	17,884,857	674,354	10,217	28,196,187	31,060,698	13,253,301	17,549,357	658,816	9,982
420	32,744,905	34,193,487	15,391,375	19,157,910	722,499	10,947	30,115,749	33,278,283	14,155,569	18,798,446	705,852	10,695

	Manual						Result and Ranking					
							Graphed Results			Ranking Results		
Test	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
361	1,898,551	729,572	892,393	431,168	16,152	245	(£ 4,305,102.)	(£ 4,167,121.)	(£ 4,162,267.)	3rd Most expensive	2nd Cheapest	1st Cheapest
362	2,408,667	1,420,361	1,132,167	786,739	31,445	476	(£ 5,984,244.)	(£ 5,708,280.)	(£ 5,698,573.)	3rd Most expensive	2nd Cheapest	1st Cheapest
363	2,918,782	2,111,149	1,371,941	1,142,309	46,738	708	(£ 7,663,385.)	(£ 7,249,439.)	(£ 7,234,880.)	3rd Most expensive	2nd Cheapest	1st Cheapest
364	3,428,897	2,801,938	1,611,715	1,497,879	62,031	940	(£ 9,342,526.)	(£ 8,790,599.)	(£ 8,771,186.)	3rd Most expensive	2nd Cheapest	1st Cheapest
365	3,939,013	3,492,726	1,851,489	1,853,450	77,324	1,172	(£ 11,021,668.)	(£ 10,331,758.)	(£ 10,307,492.)	3rd Most expensive	2nd Cheapest	1st Cheapest
366	4,449,128	4,183,514	2,091,263	2,209,020	92,617	1,403	(£ 12,700,809.)	(£ 11,872,917.)	(£ 11,843,798.)	3rd Most expensive	2nd Cheapest	1st Cheapest
367	4,983,484	4,883,203	2,342,431	2,569,532	108,107	1,638	(£ 14,379,950.)	(£ 13,414,077.)	(£ 13,468,304.)	3rd Most expensive	1st Cheapest	2nd Cheapest
368	5,500,211	5,576,419	2,585,312	2,926,451	123,454	1,871	(£ 16,059,092.)	(£ 14,955,236.)	(£ 15,028,665.)	3rd Most expensive	1st Cheapest	2nd Cheapest
369	6,016,937	6,269,634	2,828,194	3,283,369	138,801	2,103	(£ 17,738,233.)	(£ 16,496,395.)	(£ 16,589,026.)	3rd Most expensive	1st Cheapest	2nd Cheapest
370	6,533,664	6,962,850	3,071,075	3,640,287	154,148	2,336	(£ 19,417,374.)	(£ 18,037,555.)	(£ 18,149,387.)	3rd Most expensive	1st Cheapest	2nd Cheapest
371	7,050,390	7,656,066	3,313,957	3,997,205	169,495	2,568	(£ 21,181,709.)	(£ 19,578,714.)	(£ 19,709,747.)	3rd Most expensive	1st Cheapest	2nd Cheapest
372	7,567,117	8,349,281	3,556,838	4,354,123	184,842	2,801	(£ 22,875,885.)	(£ 21,119,873.)	(£ 21,270,108.)	3rd Most expensive	1st Cheapest	2nd Cheapest
373	8,083,843	9,042,497	3,799,720	4,711,042	200,189	3,033	(£ 24,570,060.)	(£ 22,661,033.)	(£ 22,830,469.)	3rd Most expensive	1st Cheapest	2nd Cheapest
374	8,624,811	9,744,613	4,053,995	5,072,902	215,732	3,269	(£ 26,352,436.)	(£ 24,290,392.)	(£ 24,479,030.)	3rd Most expensive	1st Cheapest	2nd Cheapest
375	9,144,843	10,439,042	4,298,431	5,430,494	231,106	3,502	(£ 28,058,638.)	(£ 25,843,579.)	(£ 26,051,418.)	3rd Most expensive	1st Cheapest	2nd Cheapest
376	9,664,875	11,133,471	4,542,866	5,788,087	246,480	3,735	(£ 29,764,841.)	(£ 27,476,948.)	(£ 27,623,806.)	3rd Most expensive	1st Cheapest	2nd Cheapest
377	10,207,826	11,836,315	4,798,074	6,150,351	262,040	3,970	(£ 31,554,433.)	(£ 29,123,546.)	(£ 29,279,583.)	3rd Most expensive	1st Cheapest	2nd Cheapest
378	10,730,503	12,531,716	5,043,752	6,508,483	277,435	4,204	(£ 33,270,258.)	(£ 30,696,377.)	(£ 30,861,593.)	3rd Most expensive	1st Cheapest	2nd Cheapest
379	11,253,179	13,227,116	5,289,430	6,866,614	292,830	4,437	(£ 34,986,082.)	(£ 32,269,209.)	(£ 32,443,603.)	3rd Most expensive	1st Cheapest	2nd Cheapest
380	11,775,856	13,922,516	5,535,109	7,224,745	308,226	4,670	(£ 36,701,907.)	(£ 33,842,040.)	(£ 34,025,613.)	3rd Most expensive	1st Cheapest	2nd Cheapest
381	12,298,532	14,617,917	5,780,787	7,582,877	323,621	4,903	(£ 38,417,731.)	(£ 35,414,871.)	(£ 35,607,623.)	3rd Most expensive	1st Cheapest	2nd Cheapest
382	12,821,209	15,313,317	6,026,465	7,941,008	339,016	5,137	(£ 40,133,556.)	(£ 36,987,702.)	(£ 37,189,632.)	3rd Most expensive	1st Cheapest	2nd Cheapest
383	13,343,886	16,008,717	6,272,144	8,299,139	354,411	5,370	(£ 41,849,380.)	(£ 38,560,533.)	(£ 38,771,642.)	3rd Most expensive	1st Cheapest	2nd Cheapest
384	13,866,562	16,704,117	6,517,822	8,657,271	369,806	5,603	(£ 43,565,205.)	(£ 40,133,365.)	(£ 40,353,652.)	3rd Most expensive	1st Cheapest	2nd Cheapest
385	14,389,239	17,399,518	6,763,500	9,015,402	385,202	5,836	(£ 45,281,029.)	(£ 41,706,196.)	(£ 41,935,662.)	3rd Most expensive	1st Cheapest	2nd Cheapest
386	14,911,915	18,094,918	7,009,178	9,373,533	400,597	6,070	(£ 46,996,854.)	(£ 43,279,027.)	(£ 43,517,672.)	3rd Most expensive	1st Cheapest	2nd Cheapest
387	15,434,592	18,790,318	7,254,857	9,731,665	415,992	6,303	(£ 48,712,679.)	(£ 44,851,858.)	(£ 45,099,682.)	3rd Most expensive	1st Cheapest	2nd Cheapest
388	15,957,269	19,485,718	7,500,535	10,089,796	431,387	6,536	(£ 50,428,503.)	(£ 46,424,690.)	(£ 46,681,692.)	3rd Most expensive	1st Cheapest	2nd Cheapest
389	16,479,945	20,181,119	7,746,213	10,447,927	446,783	6,769	(£ 52,144,328.)	(£ 47,997,521.)	(£ 48,263,701.)	3rd Most expensive	1st Cheapest	2nd Cheapest
390	17,002,622	20,876,519	7,991,891	10,806,059	462,178	7,003	(£ 53,860,152.)	(£ 49,570,352.)	(£ 49,845,711.)	3rd Most expensive	1st Cheapest	2nd Cheapest
391	2,718,177	1,817,956	1,277,648	1,013,747	40,247	610	(£ 6,162,840.)	(£ 5,794,888.)	(£ 6,518,431.)	2nd Cheapest	1st Cheapest	3rd Most expensive
392	4,047,917	3,597,129	1,902,678	1,951,896	79,636	1,207	(£ 9,699,719.)	(£ 8,963,815.)	(£ 10,410,901.)	2nd Cheapest	1st Cheapest	3rd Most expensive
393	5,408,510	5,387,628	2,542,209	2,896,335	119,275	1,807	(£ 13,236,598.)	(£ 12,132,742.)	(£ 14,415,626.)	2nd Cheapest	1st Cheapest	3rd Most expensive
394	6,755,881	7,173,273	3,175,526	3,838,079	158,807	2,406	(£ 16,853,659.)	(£ 15,301,669.)	(£ 18,372,241.)	2nd Cheapest	1st Cheapest	3rd Most expensive
395	8,125,288	8,967,009	3,819,201	4,784,315	198,517	3,008	(£ 20,510,811.)	(£ 18,550,778.)	(£ 22,409,039.)	2nd Cheapest	1st Cheapest	3rd Most expensive
396	9,481,474	10,755,891	4,456,660	5,727,856	238,121	3,608	(£ 24,119,853.)	(£ 21,831,960.)	(£ 26,397,727.)	2nd Cheapest	1st Cheapest	3rd Most expensive
397	10,864,986	12,554,805	5,106,964	6,676,968	277,946	4,211	(£ 27,828,322.)	(£ 25,159,113.)	(£ 30,485,841.)	2nd Cheapest	1st Cheapest	3rd Most expensive
398	12,228,223	14,346,276	5,747,739	7,621,946	317,607	4,812	(£ 31,463,023.)	(£ 28,412,498.)	(£ 34,500,187.)	2nd Cheapest	1st Cheapest	3rd Most expensive
399	13,591,460	16,137,747	6,388,513	8,566,925	357,268	5,413	(£ 35,097,723.)	(£ 31,665,883.)	(£ 38,514,533.)	2nd Cheapest	1st Cheapest	3rd Most expensive
400	14,954,698	17,929,217	7,029,288	9,511,903	396,929	6,014	(£ 38,732,424.)	(£ 34,919,269.)	(£ 42,528,880.)	2nd Cheapest	1st Cheapest	3rd Most expensive
401	16,317,935	19,720,688	7,670,062	10,456,882	436,589	6,615	(£ 42,367,125.)	(£ 38,172,654.)	(£ 46,543,226.)	2nd Cheapest	1st Cheapest	3rd Most expensive
402	17,681,172	21,512,158	8,310,836	11,401,860	476,250	7,216	(£ 46,001,826.)	(£ 41,426,039.)	(£ 50,557,573.)	2nd Cheapest	1st Cheapest	3rd Most expensive
403	19,044,410	23,303,629	8,951,611	12,346,839	515,911	7,817	(£ 49,636,527.)	(£ 44,679,424.)	(£ 54,571,919.)	2nd Cheapest	1st Cheapest	3rd Most expensive
404	20,407,647	25,095,100	9,592,385	13,291,817	555,571	8,418	(£ 53,271,228.)	(£ 47,932,810.)	(£ 58,586,266.)	2nd Cheapest	1st Cheapest	3rd Most expensive
405	21,770,885	26,886,570	10,233,160	14,236,796	595,232	9,019	(£ 56,905,929.)	(£ 51,186,195.)	(£ 62,600,612.)	2nd Cheapest	1st Cheapest	3rd Most expensive
406	3,228,292	2,508,745	1,517,422	1,369,317	55,540	842	(£ 7,841,981.)	(£ 7,336,048.)	(£ 8,054,737.)	2nd Cheapest	1st Cheapest	3rd Most expensive
407	5,094,593	4,988,415	2,394,656	2,668,428	110,437	1,673	(£ 13,058,002.)	(£ 12,046,134.)	(£ 13,579,732.)	2nd Cheapest	1st Cheapest	3rd Most expensive
408	6,958,690	7,467,275	3,270,854	3,967,090	165,315	2,505	(£ 18,359,215.)	(£ 16,756,220.)	(£ 19,096,708.)	2nd Cheapest	1st Cheapest	3rd Most expensive
409	8,849,231	9,955,845	4,159,482	5,271,143	220,409	3,340	(£ 23,726,579.)	(£ 21,562,525.)	(£ 24,709,902.)	2nd Cheapest	1st Cheapest	3rd Most expensive
410	10,751,894	12,448,865	5,053,807	6,577,668	275,601	4,176	(£ 29,138,043.)	(£ 26,516,498.)	(£ 30,367,197.)	2nd Cheapest	1st Cheapest	3rd Most expensive
411	12,637,808	14,935,736	5,940,260	7,880,778	330,657	5,010	(£ 34,488,568.)	(£ 31,342,715.)	(£ 35,963,553.)	2nd Cheapest	1st Cheapest	3rd Most expensive
412	14,523,722	17,422,607	6,826,712	9,183,887	385,713	5,844	(£ 39,839,094.)	(£ 36,168,931.)	(£ 41,559,910.)	2nd Cheapest	1st Cheapest	3rd Most expensive
413	16,409,636	19,909,478	7,713,165	10,486,997	440,769	6,678	(£ 45,189,619.)	(£ 40,995,148.)	(£ 47,156,266.)	2nd Cheapest	1st Cheapest	3rd Most expensive
414	18,295,550	22,396,349	8,599,618	11,790,107	495,825	7,512	(£ 50,540,145.)	(£ 45,821,364.)	(£ 52,752,622.)	2nd Cheapest	1st Cheapest	3rd Most expensive
415	20,181,464	24,883,220	9,486,070	13,093,217	550,881	8,347	(£ 55,890,670.)	(£ 50,647,581.)	(£ 58,348,979.)	2nd Cheapest	1st Cheapest	3rd Most expensive
416	22,067,378	27,370,091	10,372,523	14,396,326	605,937	9,181	(£ 61,241,195.)	(£ 55,473,797.)	(£ 63,945,335.)	2nd Cheapest	1st Cheapest	3rd Most expensive
417	23,953,292	29,856,961	11,258,976	15,699,436	660,993	10,015	(£ 66,591,721.)	(£ 60,300,014.)	(£ 69,541,691.)	2nd Cheapest	1st Cheapest	3rd Most expensive
418	25,839,206	32,343,832	12,145,428	17,002,546	716,049	10,849	(£ 71,942,246.)	(£ 65,126,230.)	(£ 75,138,048.)	2nd Cheapest	1st Cheapest	3rd Most expensive
419	27,725,120	34,830,703	13,031,881	18,305,656	771,104	11,683	(£ 77,292,772.)	(£ 69,952,447.)	(£ 80,734,404.)	2nd Cheapest	1st Cheapest	3rd Most expensive
420	29,611,033	37,317,574	13,918,334	19,608,765	826,160	12,518	(£ 82,643,297.)	(£ 74,778,663.)	(£ 86,330,760.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX H RESULTS WORKSHEET CONTINUED

																																						Result and Ranking					
			Graphed Results		Sensitivities															Fully Automated						Semi Automated						Manual						Graphed Results			Ranking Results		
		Test	Pax/Hour	Bags/Hour	# of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflatin Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m^2	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
High Staff loading Rate Bags/Min	Short Haul Only	421	180	180	1	0	0%		0.59			0.59			3		3			1,971,621	816,498	926,738	398,128	17,090	259	1,925,196	800,529	904,917	395,854	16,803	255	1,898,551	728,253	892,393	399,316	16,123	244	(£ 4,124,544.)	(£ 4,020,194.)	(£ 3,945,426.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		422	360	360	2	0	0%		0.59			0.59			3		3			2,554,807	1,594,212	1,200,858	720,657	33,322	505	2,461,956	1,562,273	1,157,215	716,111	32,747	496	2,408,667	1,417,722	1,132,167	723,033	31,386	476	(£ 5,536,506.)	(£ 5,327,804.)	(£ 5,178,268.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		423	540	540	3	0	0%		0.59			0.59			3		3			3,137,993	2,371,926	1,474,978	1,043,187	49,554	751	2,998,716	2,324,018	1,409,513	1,036,367	48,691	738	2,918,782	2,107,192	1,371,941	1,046,751	46,650	707	(£ 6,948,467.)	(£ 6,635,415.)	(£ 6,411,111.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		424	720	720	4	0	0%		0.59			0.59			3		3			3,721,178	3,149,640	1,749,098	1,365,717	65,786	997	3,535,476	3,085,762	1,661,811	1,356,623	64,635	979	3,428,897	2,796,661	1,611,715	1,370,469	61,914	938	(£ 8,360,429.)	(£ 7,943,026.)	(£ 7,643,954.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		425	900	900	5	0	0%		0.59			0.59			3		3			4,304,364	3,927,354	2,023,218	1,688,246	82,018	1,243	4,072,236	3,847,507	1,914,109	1,676,880	80,579	1,221	3,939,013	3,486,130	1,851,489	1,694,186	77,178	1,169	(£ 9,772,390.)	(£ 9,250,637.)	(£ 8,876,796.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		426	1080	1080	6	0	0%		0.59			0.59			3		3			4,887,549	4,705,068	2,297,338	2,010,776	98,250	1,489	4,608,996	4,609,251	2,166,407	1,997,136	96,523	1,462	4,449,128	4,175,599	2,091,263	2,017,904	92,442	1,401	(£ 11,184,352.)	(£ 10,558,248.)	(£ 10,109,639.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		427	1260	1260	7	0	0%		0.59			0.59			3		3			5,470,735	5,482,782	2,571,457	2,333,305	114,482	1,735	5,145,756	5,370,996	2,418,705	2,317,392	112,467	1,704	4,983,484	4,873,969	2,342,431	2,346,564	107,903	1,635	(£ 12,596,313.)	(£ 11,865,859.)	(£ 11,436,505.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		428	1440	1440	8	0	0%		0.59			0.59			3		3			6,053,920	6,260,496	2,845,577	2,655,835	130,714	1,981	5,682,516	6,132,740	2,671,003	2,637,649	128,411	1,946	5,500,211	5,565,865	2,585,312	2,671,630	123,221	1,867	(£ 14,008,275.)	(£ 13,173,469.)	(£ 12,694,990.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		429	1620	1620	9	0	0%		0.59			0.59			3		3			6,637,106	7,038,210	3,119,697	2,978,365	146,945	2,226	6,219,276	6,894,485	2,923,301	2,957,905	144,355	2,187	6,016,937	6,257,762	2,828,194	2,996,695	138,538	2,099	(£ 15,420,236.)	(£ 14,481,080.)	(£ 13,953,475.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		430	1800	1800	10	0	0%		0.59			0.59			3		3			7,220,291	7,815,924	3,393,817	3,300,894	163,177	2,472	6,756,036	7,656,229	3,175,599	3,278,161	160,299	2,429	6,533,664	6,949,658	3,071,075	3,321,761	153,856	2,331	(£ 16,832,198.)	(£ 15,788,691.)	(£ 15,211,960.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		431	1980	1980	11	0	0%		0.59			0.59			3		3			7,826,892	8,602,235	3,678,942	3,628,198	179,599	2,721	7,292,796	8,417,974	3,427,897	3,598,417	176,243	2,670	7,050,390	7,641,555	3,313,957	3,646,827	169,174	2,563	(£ 18,334,977.)	(£ 17,096,302.)	(£ 16,470,446.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		432	2160	2160	12	0	0%		0.59			0.59			3		3			8,414,209	9,381,466	3,955,004	3,951,570	195,865	2,968	7,829,556	9,179,718	3,680,195	3,918,674	192,187	2,912	7,567,117	8,333,451	3,556,838	3,971,892	184,491	2,795	(£ 19,762,965.)	(£ 18,403,913.)	(£ 17,728,931.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		433	2340	2340	13	0	0%		0.59			0.59			3		3			9,001,527	10,160,697	4,231,066	4,274,942	212,130	3,214	8,366,316	9,941,463	3,932,493	4,238,930	208,131	3,154	8,083,843	9,025,348	3,799,720	4,296,958	199,809	3,027	(£ 21,190,953.)	(£ 19,711,523.)	(£ 18,987,416.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		434	2520	2520	14	0	0%		0.59			0.59			3		3			9,613,085	10,948,828	4,518,523	4,603,256	228,593	3,464	8,927,317	10,712,107	4,196,185	4,564,129	224,272	3,398	8,624,811	9,726,144	4,053,995	4,626,966	215,324	3,262	(£ 22,712,964.)	(£ 21,113,157.)	(£ 20,339,924.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		435	2700	2700	15	0	0%		0.59			0.59			3		3			10,203,708	11,729,273	4,796,138	4,927,302	244,885	3,710	9,467,383	11,475,065	4,450,037	4,885,059	240,243	3,640	9,144,843	10,419,254	4,298,431	4,952,705	230,668	3,495	(£ 24,153,773.)	(£ 22,433,589.)	(£ 21,611,231.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		436	2880	2880	16	0	0%		0.59			0.59			3		3			10,794,332	12,509,717	5,073,754	5,251,348	261,177	3,957	10,029,486	12,246,115	4,714,247	5,210,482	256,393	3,885	9,664,875	11,112,365	4,542,866	5,278,445	246,013	3,727	(£ 25,594,582.)	(£ 23,839,496.)	(£ 22,882,537.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		437	3060	3060	17	0	0%		0.59			0.59			3		3			11,407,873	13,298,577	5,362,143	5,580,067	277,656	4,207	10,595,225	13,018,499	4,980,167	5,536,647	272,573	4,130	10,207,826	11,813,889	4,798,074	5,608,857	261,543	3,963	(£ 27,124,286.)	(£ 25,259,507.)	(£ 24,242,738.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		438	3240	3240	18	0	0%		0.59			0.59			3		3			12,001,141	14,079,992	5,641,002	5,904,652	293,970	4,454	11,140,690	13,783,439	5,236,556	5,858,678	288,587	4,373	10,730,503	12,507,970	5,043,752	5,935,136	276,909	4,196	(£ 28,575,352.)	(£ 26,600,881.)	(£ 25,524,302.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		439	3420	3420	19	0	0%		0.59			0.59			3		3			12,594,409	14,861,408	5,919,860	6,229,238	310,284	4,701	11,686,155	14,548,380	5,492,946	6,180,709	304,602	4,615	11,253,179	13,202,051	5,289,430	6,261,414	292,275	4,428	(£ 30,026,419.)	(£ 27,942,254.)	(£ 26,805,865.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		440	3600	3600	20	0	0%		0.59			0.59			3		3			13,187,676	15,642,824	6,198,719	6,553,823	326,597	4,948	12,231,619	15,313,320	5,749,335	6,502,740	320,617	4,858	11,775,856	13,896,133	5,535,109	6,587,693	307,641	4,661	(£ 31,477,485.)	(£ 29,283,628.)	(£ 28,087,429.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		441	3780	3780	21	0	0%		0.59			0.59			3		3			13,780,944	16,424,239	6,477,578	6,878,408	342,911	5,196	12,777,084	16,078,261	6,005,725	6,824,771	336,632	5,100	12,298,532	14,590,214	5,780,787	6,913,972	323,008	4,894	(£ 32,928,552.)	(£ 30,625,001.)	(£ 29,368,993.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		442	3960	3960	22	0	0%		0.59			0.59			3		3			14,374,212	17,205,655	6,756,437	7,202,993	359,225	5,443	13,322,549	16,843,201	6,262,115	7,146,802	352,647	5,343	12,821,209	15,284,295	6,026,465	7,240,251	338,374	5,127	(£ 34,379,618.)	(£ 31,966,375.)	(£ 30,650,556.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		443	4140	4140	23	0	0%		0.59			0.59			3		3			14,967,479	17,987,070	7,035,295	7,527,578	375,539	5,690	13,868,014	17,608,141	6,518,504	7,468,833	368,661	5,586	13,343,886	15,978,376	6,272,144	7,566,529	353,740	5,360	(£ 35,830,684.)	(£ 33,307,748.)	(£ 31,932,120.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		444	4320	4320	24	0	0%		0.59			0.59			3		3			15,560,747	18,768,486	7,314,154	7,852,164	391,853	5,937	14,413,479	18,373,082	6,774,894	7,790,864	384,676	5,828	13,866,562	16,672,457	6,517,822	7,892,808	369,106	5,593	(£ 37,281,751.)	(£ 34,649,122.)	(£ 33,213,683.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		445	4500	4500	25	0	0%		0.59			0.59			3		3			16,154,014	19,549,902	7,593,013	8,176,749	408,167	6,184	14,958,943	19,138,022	7,031,283	8,112,895	400,691	6,071	14,389,239	17,366,538	6,763,500	8,219,087	384,472	5,825	(£ 38,732,817.)	(£ 35,990,496.)	(£ 34,495,247.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		446	4680	4680	26	0	0%		0.59			0.59			3		3			16,747,282	20,331,317	7,871,872	8,501,334	424,480	6,432	15,504,408	19,902,963	7,287,673	8,434,926	416,706	6,314	14,911,915	18,060,619	7,009,178	8,545,365	399,838	6,058	(£ 40,183,884.)	(£ 37,331,869.)	(£ 35,776,811.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		447	4860	4860	27	0	0%		0.59			0.59			3		3			17,340,550	21,112,733	8,150,731	8,825,919	440,794	6,679	16,049,873	20,667,903	7,544,062	8,756,957	432,720	6,556	15,434,592	18,754,700	7,254,857	8,871,644	415,204	6,291	(£ 41,634,950.)	(£ 38,673,243.)	(£ 37,058,374.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		448	5040	5040	28	0	0%		0.59			0.59			3		3			17,933,817	21,894,149	8,429,589	9,150,504	457,108	6,926	16,595,338	21,432,844	7,800,452	9,078,988	448,735	6,799	15,957,269	19,448,781	7,500,535	9,197,923	430,570	6,524	(£ 43,086,016.)	(£ 40,014,616.)	(£ 38,339,938.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		449	5220	5220	29	0	0%		0.59			0.59			3		3			18,527,085	22,675,564	8,708,448	9,475,090	473,422	7,173	17,140,802	22,197,784	8,056,842	9,401,020	464,750	7,042	16,479,945	20,142,862	7,746,213	9,524,202	445,936	6,757	(£ 44,537,083.)	(£ 41,355,990.)	(£ 39,621,501.)	3rd Most expensive	2nd Cheapest	1st Cheapest
		450	5400	5400	30	0	0%		0.59			0.59			3		3			19,120,352	23,456,980	8,987,307	9,799,675	489,736	7,420	17,686,267	22,962,725	8,313,231	9,723,051	480,765	7,284	17,002,622	20,836,943	7,991,891	9,850,480	461,302	6,989	(£ 45,988,149.)	(£ 42,697,363.)	(£ 40,903,065.)	3rd Most expensive	2nd Cheapest	1st Cheapest
	Long Haul Only	451	400	480	0	1	0%		0.59			0.59			3		3			2,863,121	1,521,863	1,345,778	916,390	32,378	491	2,739,320	1,479,278	1,287,587	910,328	31,610	479	2,718,177	1,814,439	1,277,648	928,807	40,169	609	(£ 5,501,801.)	(£ 5,223,533.)	(£ 5,782,865.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		452	800	960	0	2	0%		0.59			0.59			3		3			4,337,807	3,004,943	2,038,937	1,757,183	63,897	968	4,090,204	2,919,772	1,922,555	1,745,058	62,362	945	4,047,917	3,590,093	1,902,678	1,782,016	79,480	1,204	(£ 8,291,019.)	(£ 7,734,483.)	(£ 8,853,148.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		453	1200	1440	0	3	0%		0.59			0.59			3		3			5,812,493	4,488,022	2,732,097	2,597,975	95,416	1,446	5,441,089	4,360,266	2,557,523	2,579,788	93,113	1,411	5,408,510	5,377,075	2,542,209	2,641,515	119,041	1,804	(£ 11,080,238.)	(£ 10,245,432.)	(£ 12,043,096.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		454	1600	1920	0	4	0%		0.59			0.59			3		3			7,309,216	5,979,193	3,435,615	3,443,260	127,114	1,926	6,791,973	5,800,760	3,192,491	3,414,518	123,865	1,877	6,755,881	7,159,202	3,175,526	3,498,318	158,495	2,401	(£ 13,954,931.)	(£ 12,756,382.)	(£ 15,181,759.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		455	2000	2400	0	5	0%		0.59			0.59			3		3			8,816,957	7,474,408	4,144,312	4,290,792	158,902	2,408	8,164,894	7,249,345	3,837,817	4,253,741	154,796	2,345	8,125,288	8,949,420	3,819,201	4,359,614	198,128	3,002	(£ 16,872,362.)	(£ 15,352,807.)	(£ 18,405,897.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		456	2400	2880	0	6	0%		0.59			0.59			3		3			10,311,476	8,964,770	4,846,794	5,135,628	190,582	2,888	9,546,631	8,701,167	4,487,287	5,094,762	185,798	2,815	9,481,474	10,734,784	4,456,660	5,218,214	237,654	3,601	(£ 19,738,508.)	(£ 17,983,422.)	(£ 21,578,750.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		457	2800	3360	0	7	0%		0.59			0.59			3		3			11,833,322	10,465,164	5,562,120	5,986,035	222,485	3,371	10,941,002	10,157,627	5,142,695	5,938,358	216,903	3,286	10,864,986	12,530,180	5,106,964	6,082,386	277,401	4,203	(£ 22,710,644.)	(£ 20,663,043.)	(£ 24,857,592.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		458	3200	3840	0	8	0%		0.59			0.59			3		3			13,334,893	11,958,114	6,267,917	6,832,309	254,223	3,852	12,315,099	11,606,644	5,788,574	6,777,821	247,843	3,755	12,228,223	14,318,133	5,747,739	6,942,424	316,984	4,803	(£ 25,604,142.)	(£ 23,264,027.)	(£ 28,057,797.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		459	3600	4320	0	9	0%		0.59			0.59			3		3			14,836,464	13,451,065	6,973,713	7,678,583	285,960	4,333	13,689,196	13,055,660	6,434,453	7,617,283	278,784	4,224	13,591,460	16,106,086	6,388,513	7,802,462	356,567	5,403	(£ 28,497,640.)	(£ 25,865,011.)	(£ 31,258,002.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		460	4000	4800	0	10	0%		0.59			0.59			3		3			16,338,035	14,944,015	7,679,510	8,524,856	317,698	4,814	15,063,293	14,504,677	7,080,332	8,456,746	309,724	4,693	14,954,698	17,894,039	7,029,288	8,662,500	396,150	6,002	(£ 31,391,138.)	(£ 28,465,995.)	(£ 34,458,207.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		461	4400	5280	0	11	0%		0.59			0.59			3		3			17,839,606	16,436,965	8,385,307	9,371,130	349,436	5,294	16,437,390	15,953,694	7,726,210	9,296,209	340,664	5,162	16,317,935	19,681,992	7,670,062	9,522,538	435,733	6,602	(£ 34,284,636.)	(£ 31,066,978.)	(£ 37,658,412.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		462	4800	5760	0	12	0%		0.59			0.59			3		3			19,341,177	17,929,916	9,091,103	10,217,404	381,173	5,775	17,811,486	17,402,710	8,372,089	10,135,672	371,604	5,630	17,681,172	21,469,944	8,310,836	10,382,577	475,315	7,202	(£ 37,178,134.)	(£ 33,667,962.)	(£ 40,858,617.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		463	5200	6240	0	13	0%		0.59			0.59			3		3			20,842,749	19,422,866	9,796,900	11,063,678	412,911	6,256	19,185,583	18,851,727	9,017,968	10,975,134	402,545	6,099	19,044,410	23,257,897	8,951,611	11,242,615	514,898	7,801	(£ 40,071,632.)	(£ 36,268,946.)	(£ 44,058,822.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		464	5600	6720	0	14	0%		0.59			0.59			3		3			22,344,320	20,915,817	10,502,696	11,909,951	444,649	6,737	20,559,680	20,300,743	9,663,847	11,814,597	433,485	6,568	20,407,647	25,045,850	9,592,385	12,102,653	554,481	8,401	(£ 42,965,130.)	(£ 38,869,930.)	(£ 47,259,027.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		465	6000	7200	0	15	0%		0.59			0.59			3		3			23,845,891	22,408,767	11,208,493	12,756,225	476,386	7,218	21,933,777	21,749,760	10,309,726	12,654,060	464,425	7,037	21,770,885	26,833,803	10,233,160	12,962,691	594,064	9,001	(£ 45,858,628.)	(£ 41,470,913.)	(£ 50,459,231.)	2nd Cheapest	1st Cheapest	3rd Most expensive
	Short Haul and Long Haul Mix	466	580	660	1	1	0%		0.59			0.59			3		3			3,446,307	2,299,577	1,619,898	1,238,920	48,610	737	3,276,080	2,241,023	1,539,885	1,230,584	47,554	721	3,228,292	2,503,908	1,517,422	1,252,524	55,433	840	(£ 6,913,763.)	(£ 6,531,143.)	(£ 7,015,708.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		467	1160	1320	2	2	0%		0.59			0.59			3		3			5,504,178	4,560,371	2,587,177	2,402,242	96,361	1,460	5,163,724	4,443,261	2,427,151	2,385,571	94,250	1,428	5,094,593	4,978,741	2,394,656	2,434,843	110,223	1,670	(£ 11,114,942.)	(£ 10,349,704.)	(£ 11,421,404.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		468	1740	1980	3	3	0%		0.59			0.59			3		3			7,585,464	6,829,761	3,565,462	3,570,338	144,302	2,186	7,051,369	6,645,500	3,314,417	3,540,557	140,945	2,136	6,958,690	7,452,764	3,270,854	3,616,711	164,994	2,500	(£ 15,406,940.)	(£ 14,168,265.)	(£ 15,818,552.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		469	2320	2640	4	4	0%		0.59			0.59			3		3			9,684,931	9,105,826	4,552,293	4,742,140	192,391	2,915	8,965,458	8,857,448	4,214,113	4,700,935	187,856	2,846	8,849,231	9,936,497	4,159,482	4,803,972	219,981	3,333	(£ 19,769,454.)	(£ 18,089,396.)	(£ 20,318,270.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		470	2900	3300	5	5	0%		0.59			0.59			3		3			11,796,518	11,386,341	5,544,821	5,916,414	240,579	3,645	10,920,132	11,084,296	5,132,885	5,869,588	235,096	3,562	10,751,894	12,424,680	5,053,807	5,993,703	275,066	4,168	(£ 24,178,980.)	(£ 22,167,944.)	(£ 24,865,000.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		471	3480	3960	6	6	0%		0.59			0.59			3		3			13,891,356	13,660,707	6,529,476	7,087,273	288,630	4,373	12,839,694	13,298,253	6,035,154	7,031,082	282,052	4,274	12,637,808	14,906,714	5,940,260	7,180,020	330,014	5,000	(£ 28,523,544.)	(£ 26,110,301.)	(£ 29,346,768.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		472	4060	4620	7	7	0%		0.59			0.59			3		3			15,986,195	15,935,073	7,514,131	8,258,132	336,682	5,101	14,759,256	15,512,210	6,937,422	8,192,575	329,007	4,985	14,523,722	17,388,748	6,826,712	8,366,337	384,963	5,833	(£ 32,868,108.)	(£ 30,052,658.)	(£ 33,828,537.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		473	4640	5280	8	8	0%		0.59			0.59			3		3			18,081,034	18,209,439	8,498,787	9,428,990	384,733	5,829	16,678,817	17,726,167	7,839,691	9,354,069	375,962	5,696	16,409,636	19,870,782	7,713,165	9,552,654	439,912	6,665	(£ 37,212,673.)	(£ 33,995,015.)	(£ 38,310,306.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		474	5220	5940	9	9	0%		0.59			0.59			3		3			20,175,873	20,483,805	9,483,442	10,599,849	432,785	6,557	18,598,379	19,940,124	8,741,959	10,515,563	422,917	6,408	18,295,550	22,352,816	8,599,618	10,738,971	494,861	7,498	(£ 41,557,237.)	(£ 37,937,373.)	(£ 42,792,074.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		475	5800	6600	10	10	0%		0.59			0.59			3		3			22,270,711	22,758,171	10,468,098	11,770,708	480,836	7,285	20,517,940	22,154,081	9,644,227	11,677,057	469,872	7,119	20,181,464	24,834,850	9,486,070	11,925,287	549,810	8,330	(£ 45,901,802.)	(£ 41,879,730.)	(£ 47,273,843.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		476	6380	7260	11	11	0%		0.59			0.59			3		3			24,365,550	25,032,537	11,452,753	12,941,567	528,888	8,013	22,437,502	24,368,039	10,546,496	12,838,550	516,827	7,831	22,067,378	27,316,883	10,372,523	13,111,604	604,759	9,163	(£ 50,246,366.)	(£ 45,822,087.)	(£ 51,755,611.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		477	6960	7920	12	12	0%		0.59			0.59			3		3			26,460,389	27,306,903	12,437,408	14,112,426	576,939	8,742	24,357,064	26,581,996	11,448,764	14,000,044	563,782	8,542	23,953,292	29,798,917	11,258,976	14,297,921	659,708	9,996	(£ 54,590,931.)	(£ 49,764,445.)	(£ 56,237,380.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		478	7540	8580	13	13	0%		0.59			0.59			3		3			28,555,228	29,581,269	13,422,064	15,283,285	624,990	9,470	26,276,625	28,795,953	12,351,033	15,161,538	610,737	9,254	25,839,206	32,280,951	12,145,428	15,484,238	714,656	10,828	(£ 58,935,495.)	(£ 53,706,802.)	(£ 60,719,148.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		479	8120	9240	14	14	0%		0.59			0.59			3		3			30,650,066	31,855,635	14,406,719	16,454,144	673,042	10,198	28,196,187	31,009,910	13,253,301	16,323,032	657,692	9,965	27,725,120	34,762,985	13,031,881	16,670,555	769,605	11,661	(£ 63,280,060.)	(£ 57,649,159.)	(£ 65,200,917.)	2nd Cheapest	1st Cheapest	3rd Most expensive
		480	8700	9900	15	15	0%		0.59			0.59			3		3			32,744,905	34,130,001	15,391,375	17,625,003	721,093	10,926	30,115,749	33,223,867	14,155,569	17,484,525	704,647	10,676	29,611,033	37,245,019	13,918,334	17,856,872	824,554	12,493	(£ 67,624,624.)	(£ 61,591,517.)	(£ 69,682,685.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX H RESULTS WORKSHEET CONTINUED

			Graphed Results		Sensitivities														
		Test	Pax/Hour	Bags/Hour	# of Short Haul Flights / Hour	# of Long Haul Flights / Hour	Peaking Factor %	High CAPEX Factor	Base Medium CAPEX Factor	Low CAPEX Factor	High OPEX Factor	Base Medium OPEX Factor	Low OPEX Factor	High Inflation Rate %	Base Inflation Rate %	Low Inflation Rate %	High Staff loading Rate Bags/Min	Base Staff Loading Rate Bags/Min	Low Loading Rate Bags/Min
Low Loading Rate Bags/Min	Short Haul Only	481	180	180	1	0	0%		0.59			0.59			3				1
		482	360	360	2	0	0%		0.59			0.59			3				1
		483	540	540	3	0	0%		0.59			0.59			3				1
		484	720	720	4	0	0%		0.59			0.59			3				1
		485	900	900	5	0	0%		0.59			0.59			3				1
		486	1080	1080	6	0	0%		0.59			0.59			3				1
		487	1260	1260	7	0	0%		0.59			0.59			3				1
		488	1440	1440	8	0	0%		0.59			0.59			3				1
		489	1620	1620	9	0	0%		0.59			0.59			3				1
		490	1800	1800	10	0	0%		0.59			0.59			3				1
		491	1980	1980	11	0	0%		0.59			0.59			3				1
		492	2160	2160	12	0	0%		0.59			0.59			3				1
		493	2340	2340	13	0	0%		0.59			0.59			3				1
		494	2520	2520	14	0	0%		0.59			0.59			3				1
		495	2700	2700	15	0	0%		0.59			0.59			3				1
		496	2880	2880	16	0	0%		0.59			0.59			3				1
		497	3060	3060	17	0	0%		0.59			0.59			3				1
		498	3240	3240	18	0	0%		0.59			0.59			3				1
		499	3420	3420	19	0	0%		0.59			0.59			3				1
		500	3600	3600	20	0	0%		0.59			0.59			3				1
		501	3780	3780	21	0	0%		0.59			0.59			3				1
		502	3960	3960	22	0	0%		0.59			0.59			3				1
		503	4140	4140	23	0	0%		0.59			0.59			3				1
		504	4320	4320	24	0	0%		0.59			0.59			3				1
		505	4500	4500	25	0	0%		0.59			0.59			3				1
		506	4680	4680	26	0	0%		0.59			0.59			3				1
		507	4860	4860	27	0	0%		0.59			0.59			3				1
		508	5040	5040	28	0	0%		0.59			0.59			3				1
		509	5220	5220	29	0	0%		0.59			0.59			3				1
		510	5400	5400	30	0	0%		0.59			0.59			3				1
	Long Haul Only	511	400	480	0	1	0%		0.59			0.59			3				1
		512	800	960	0	2	0%		0.59			0.59			3				1
		513	1200	1440	0	3	0%		0.59			0.59			3				1
		514	1600	1920	0	4	0%		0.59			0.59			3				1
		515	2000	2400	0	5	0%		0.59			0.59			3				1
		516	2400	2880	0	6	0%		0.59			0.59			3				1
		517	2800	3360	0	7	0%		0.59			0.59			3				1
		518	3200	3840	0	8	0%		0.59			0.59			3				1
		519	3600	4320	0	9	0%		0.59			0.59			3				1
		520	4000	4800	0	10	0%		0.59			0.59			3				1
		521	4400	5280	0	11	0%		0.59			0.59			3				1
		522	4800	5760	0	12	0%		0.59			0.59			3				1
		523	5200	6240	0	13	0%		0.59			0.59			3				1
		524	5600	6720	0	14	0%		0.59			0.59			3				1
		525	6000	7200	0	15	0%		0.59			0.59			3				1
	Short Haul and Long Haul Mix	526	580	660	1	1	0%		0.59			0.59			3				1
		527	1160	1320	2	2	0%		0.59			0.59			3				1
		528	1740	1980	3	3	0%		0.59			0.59			3				1
		529	2320	2640	4	4	0%		0.59			0.59			3				1
		530	2900	3300	5	5	0%		0.59			0.59			3				1
		531	3480	3960	6	6	0%		0.59			0.59			3				1
		532	4060	4620	7	7	0%		0.59			0.59			3				1
		533	4640	5280	8	8	0%		0.59			0.59			3				1
		534	5220	5940	9	9	0%		0.59			0.59			3				1
		535	5800	6600	10	10	0%		0.59			0.59			3				1
		536	6380	7260	11	11	0%		0.59			0.59			3				1
		537	6960	7920	12	12	0%		0.59			0.59			3				1
		538	7540	8580	13	13	0%		0.59			0.59			3				1
		539	8120	9240	14	14	0%		0.59			0.59			3				1
		540	8700	9900	15	15	0%		0.59			0.59			3				1

	Fully Automated						Semi Automated					
Test	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²
481	1,971,621	821,115	926,738	509,612	17,193	260	1,925,196	804,486	904,917	491,412	16,890	256
482	2,554,807	1,603,446	1,200,858	943,626	33,527	508	2,461,956	1,570,188	1,157,215	907,226	32,922	499
483	3,137,993	2,385,778	1,474,978	1,377,639	49,861	755	2,998,716	2,335,890	1,409,513	1,323,040	48,954	742
484	3,721,178	3,168,109	1,749,098	1,811,653	66,195	1,003	3,535,476	3,101,592	1,661,811	1,738,855	64,985	985
485	4,304,364	3,950,440	2,023,218	2,245,667	82,529	1,250	4,072,236	3,867,294	1,914,109	2,154,669	81,017	1,228
486	4,887,549	4,732,771	2,297,338	2,679,681	98,863	1,498	4,608,996	4,632,996	2,166,407	2,570,483	97,049	1,470
487	5,470,735	5,515,102	2,571,457	3,113,694	115,197	1,745	5,145,756	5,398,699	2,418,705	2,986,297	113,080	1,713
488	6,053,920	6,297,433	2,845,577	3,547,708	131,531	1,993	5,682,516	6,164,401	2,671,003	3,402,111	129,112	1,956
489	6,637,106	7,079,764	3,119,697	3,981,722	147,865	2,240	6,219,276	6,930,103	2,923,301	3,817,925	145,143	2,199
490	7,220,291	7,862,096	3,393,817	4,415,736	164,199	2,488	6,756,036	7,695,805	3,175,599	4,233,740	161,175	2,442
491	7,826,892	8,653,023	3,678,942	4,854,523	180,724	2,738	7,292,796	8,461,507	3,427,897	4,649,554	177,207	2,685
492	8,414,209	9,436,872	3,955,004	5,289,380	197,091	2,986	7,829,556	9,227,209	3,680,195	5,065,368	193,238	2,928
493	9,001,527	10,220,720	4,231,066	5,724,236	213,459	3,234	8,366,316	9,992,911	3,932,493	5,481,182	209,270	3,171
494	9,613,085	11,013,468	4,518,523	6,164,034	230,024	3,485	8,927,317	10,767,513	4,196,185	5,901,938	225,499	3,417
495	10,203,708	11,798,530	4,796,138	6,599,565	246,418	3,734	9,467,383	11,534,429	4,450,037	6,318,427	241,557	3,660
496	10,794,332	12,583,592	5,073,754	7,035,095	262,813	3,982	10,029,486	12,309,436	4,714,247	6,739,408	257,795	3,906
497	11,407,873	13,377,068	5,362,143	7,475,298	279,394	4,233	10,595,225	13,085,777	4,980,167	7,161,130	274,062	4,152
498	12,001,141	14,163,101	5,641,002	7,911,367	295,810	4,482	11,140,690	13,854,675	5,236,556	7,578,719	290,164	4,396
499	12,594,409	14,949,134	5,919,860	8,347,436	312,226	4,731	11,686,155	14,623,573	5,492,946	7,996,308	306,267	4,640
500	13,187,676	15,735,167	6,198,719	8,783,506	328,642	4,979	12,231,619	15,392,471	5,749,335	8,413,897	322,369	4,884
501	13,780,944	16,521,199	6,477,578	9,219,575	345,058	5,228	12,777,084	16,161,369	6,005,725	8,831,486	338,472	5,128
502	14,374,212	17,307,232	6,756,437	9,655,644	361,474	5,477	13,322,549	16,930,267	6,262,115	9,249,075	354,574	5,372
503	14,967,479	18,093,265	7,035,295	10,091,714	377,890	5,726	13,868,014	17,699,165	6,518,504	9,666,663	370,676	5,616
504	15,560,747	18,879,298	7,314,154	10,527,783	394,306	5,974	14,413,479	18,468,063	6,774,894	10,084,252	386,779	5,860
505	16,154,014	19,665,331	7,593,013	10,963,852	410,722	6,223	14,958,943	19,236,961	7,031,283	10,501,841	402,881	6,104
506	16,747,282	20,451,363	7,871,872	11,399,922	427,138	6,472	15,504,408	20,005,859	7,287,673	10,919,430	418,984	6,348
507	17,340,550	21,237,396	8,150,731	11,835,991	443,554	6,721	16,049,873	20,774,757	7,544,062	11,337,019	435,086	6,592
508	17,933,817	22,023,429	8,429,589	12,272,060	459,970	6,969	16,595,338	21,543,655	7,800,452	11,754,608	451,188	6,836
509	18,527,085	22,809,462	8,708,448	12,708,130	476,386	7,218	17,140,802	22,312,553	8,056,842	12,172,197	467,291	7,080
510	19,120,352	23,595,494	8,987,307	13,144,199	492,802	7,467	17,686,267	23,081,451	8,313,231	12,589,786	483,393	7,324
511	2,863,121	1,534,176	1,345,778	1,213,681	32,650	495	2,739,320	1,489,832	1,287,587	1,165,149	31,844	482
512	4,337,807	3,029,568	2,038,937	2,351,765	64,442	976	4,090,204	2,940,879	1,922,555	2,254,700	62,829	952
513	5,812,493	4,524,959	2,732,097	3,489,848	96,234	1,458	5,441,089	4,391,927	2,557,523	3,344,251	93,814	1,421
514	7,309,216	6,028,442	3,435,615	4,632,424	128,205	1,942	6,791,973	5,842,974	3,192,491	4,433,802	124,800	1,891
515	8,816,957	7,535,970	4,144,312	5,777,247	160,265	2,428	8,164,894	7,302,113	3,837,817	5,527,846	155,964	2,363
516	10,311,476	9,038,644	4,846,794	6,919,374	192,218	2,912	9,546,631	8,764,488	4,487,287	6,623,687	187,200	2,836
517	11,833,322	10,551,351	5,562,120	8,067,073	224,393	3,400	10,941,002	10,231,502	5,142,695	7,722,104	218,539	3,311
518	13,334,893	12,056,613	6,267,917	9,210,637	256,403	3,885	12,315,099	11,691,072	5,788,574	8,816,388	249,712	3,784
519	14,836,464	13,561,876	6,973,713	10,354,202	288,413	4,370	13,689,196	13,150,642	6,434,453	9,910,671	280,886	4,256
520	16,338,035	15,067,139	7,679,510	11,497,767	320,424	4,855	15,063,293	14,610,212	7,080,332	11,004,955	312,060	4,728
521	17,839,606	16,572,402	8,385,307	12,641,332	352,434	5,340	16,437,390	16,069,782	7,726,210	12,099,239	343,234	5,201
522	19,341,177	18,077,665	9,091,103	13,784,897	384,444	5,825	17,811,486	17,529,352	8,372,089	13,193,522	374,408	5,673
523	20,842,749	19,582,927	9,796,900	14,928,461	416,454	6,310	19,185,583	18,988,922	9,017,968	14,287,806	405,582	6,145
524	22,344,320	21,088,190	10,502,696	16,072,026	448,465	6,795	20,559,680	20,448,492	9,663,847	15,382,090	436,756	6,618
525	23,845,891	22,593,453	11,208,493	17,215,591	480,475	7,280	21,933,777	21,908,062	10,309,726	16,476,373	467,930	7,090
526	3,446,307	2,316,507	1,619,898	1,647,695	48,984	742	3,276,080	2,255,534	1,539,885	1,580,963	47,875	725
527	5,504,178	4,594,230	2,587,177	3,219,792	97,110	1,471	5,163,724	4,472,283	2,427,151	3,086,328	94,892	1,438
528	7,585,464	6,880,550	3,565,462	4,796,663	145,426	2,203	7,051,369	6,689,033	3,314,417	4,591,693	141,909	2,150
529	9,684,931	9,173,544	4,552,293	6,377,241	193,890	2,938	8,965,458	8,915,492	4,214,113	6,102,450	189,141	2,866
530	11,796,518	11,470,989	5,544,821	7,960,290	242,453	3,674	10,920,132	11,156,852	5,132,885	7,621,481	236,703	3,586
531	13,891,356	13,762,285	6,529,476	9,539,924	290,879	4,407	12,839,694	13,385,320	6,035,154	9,133,354	283,979	4,303
532	15,986,195	16,053,580	7,514,131	11,119,558	339,305	5,141	14,759,256	15,613,788	6,937,422	10,645,226	331,255	5,019
533	18,081,034	18,344,876	8,498,787	12,699,192	387,731	5,875	16,678,817	17,842,256	7,839,691	12,157,099	378,532	5,735
534	20,175,873	20,636,171	9,483,442	14,278,826	436,158	6,608	18,598,379	20,070,724	8,741,959	13,668,971	425,808	6,452
535	22,270,711	22,927,467	10,468,098	15,858,460	484,584	7,342	20,517,940	22,299,192	9,644,227	15,180,844	473,084	7,168
536	24,365,550	25,218,762	11,452,753	17,438,094	533,010	8,076	22,437,502	24,527,660	10,546,496	16,692,717	520,361	7,884
537	26,460,389	27,510,058	12,437,408	19,017,729	581,437	8,810	24,357,064	26,756,128	11,448,764	18,204,589	567,637	8,601
538	28,555,228	29,801,354	13,422,064	20,597,363	629,863	9,543	26,276,625	28,984,596	12,351,033	19,716,462	614,913	9,317
539	30,650,066	32,092,649	14,406,719	22,176,997	678,289	10,277	28,196,187	31,213,064	13,253,301	21,228,334	662,190	10,033
540	32,744,905	34,383,945	15,391,375	23,756,631	726,715	11,011	30,115,749	33,441,533	14,155,569	22,740,207	709,466	10,749

	Manual						Result and Ranking					
							Graphed Results			Ranking Results		
Test	Baggage CAPEX £	Building CAPEX £	On Cost CAPEX £	Baggage OPEX £	Building OPEX £	Building Area m²	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual	WLCC £ - Fully Automatic	WLCC £ - Semi Automatic	WLCC £ - Manual
481	1,898,551	733,530	892,393	526,726	16,239	246	(£ 5,273,889.)	(£ 5,005,347.)	(£ 5,258,963.)	3rd Most expensive	1st Cheapest	2nd Cheapest
482	2,408,667	1,428,276	1,132,167	977,854	31,620	479	(£ 7,835,196.)	(£ 7,298,110.)	(£ 7,805,343.)	3rd Most expensive	1st Cheapest	2nd Cheapest
483	2,918,782	2,123,022	1,371,941	1,428,982	47,001	712	(£ 10,396,503.)	(£ 9,590,874.)	(£ 10,351,723.)	3rd Most expensive	1st Cheapest	2nd Cheapest
484	3,428,897	2,817,768	1,611,715	1,880,111	62,382	945	(£ 12,957,809.)	(£ 11,883,638.)	(£ 12,898,103.)	3rd Most expensive	1st Cheapest	2nd Cheapest
485	3,939,013	3,512,514	1,851,489	2,331,239	77,762	1,178	(£ 15,519,116.)	(£ 14,176,402.)	(£ 15,444,483.)	3rd Most expensive	1st Cheapest	2nd Cheapest
486	4,449,128	4,207,260	2,091,263	2,782,367	93,143	1,411	(£ 18,080,422.)	(£ 16,469,166.)	(£ 17,990,863.)	3rd Most expensive	1st Cheapest	2nd Cheapest
487	4,983,484	4,910,906	2,342,431	3,238,437	108,721	1,647	(£ 20,641,729.)	(£ 18,761,929.)	(£ 20,631,266.)	3rd Most expensive	1st Cheapest	2nd Cheapest
488	5,500,211	5,608,079	2,585,312	3,690,913	124,155	1,881	(£ 23,203,036.)	(£ 21,054,693.)	(£ 23,203,288.)	2nd Cheapest	1st Cheapest	3rd Most expensive
489	6,016,937	6,305,252	2,828,194	4,143,389	139,590	2,115	(£ 25,764,342.)	(£ 23,347,457.)	(£ 25,775,311.)	2nd Cheapest	1st Cheapest	3rd Most expensive
490	6,533,664	7,002,426	3,071,075	4,595,865	155,024	2,349	(£ 28,325,649.)	(£ 25,640,221.)	(£ 28,347,333.)	2nd Cheapest	1st Cheapest	3rd Most expensive
491	7,050,390	7,699,599	3,313,957	5,048,341	170,459	2,583	(£ 30,977,773.)	(£ 27,932,984.)	(£ 30,919,356.)	3rd Most expensive	1st Cheapest	2nd Cheapest
492	7,567,117	8,396,772	3,556,838	5,500,818	185,893	2,817	(£ 33,555,106.)	(£ 30,225,748.)	(£ 33,491,378.)	3rd Most expensive	1st Cheapest	2nd Cheapest
493	8,083,843	9,093,945	3,799,720	5,953,294	201,328	3,050	(£ 36,132,439.)	(£ 32,518,512.)	(£ 36,063,401.)	3rd Most expensive	1st Cheapest	2nd Cheapest
494	8,624,811	9,800,019	4,053,995	6,410,712	216,959	3,287	(£ 38,803,795.)	(£ 34,905,299.)	(£ 38,729,446.)	3rd Most expensive	1st Cheapest	2nd Cheapest
495	9,144,843	10,498,406	4,298,431	6,863,862	232,420	3,522	(£ 41,393,950.)	(£ 37,210,884.)	(£ 41,314,290.)	3rd Most expensive	1st Cheapest	2nd Cheapest
496	9,664,875	11,196,792	4,542,866	7,317,012	247,882	3,756	(£ 43,984,104.)	(£ 39,601,944.)	(£ 43,899,134.)	3rd Most expensive	1st Cheapest	2nd Cheapest
497	10,207,826	11,903,594	4,798,074	7,774,835	263,529	3,993	(£ 46,663,153.)	(£ 42,007,108.)	(£ 46,572,872.)	3rd Most expensive	1st Cheapest	2nd Cheapest
498	10,730,503	12,602,952	5,043,752	8,228,524	279,012	4,227	(£ 49,263,565.)	(£ 44,333,634.)	(£ 49,167,973.)	3rd Most expensive	1st Cheapest	2nd Cheapest
499	11,253,179	13,302,310	5,289,430	8,682,213	294,495	4,462	(£ 51,863,976.)	(£ 46,660,161.)	(£ 51,763,074.)	3rd Most expensive	1st Cheapest	2nd Cheapest
500	11,775,856	14,001,667	5,535,109	9,135,902	309,978	4,697	(£ 54,464,388.)	(£ 48,986,687.)	(£ 54,358,175.)	3rd Most expensive	1st Cheapest	2nd Cheapest
501	12,298,532	14,701,025	5,780,787	9,589,591	325,461	4,931	(£ 57,064,799.)	(£ 51,313,214.)	(£ 56,953,276.)	3rd Most expensive	1st Cheapest	2nd Cheapest
502	12,821,209	15,400,383	6,026,465	10,043,280	340,944	5,166	(£ 59,665,211.)	(£ 53,639,740.)	(£ 59,548,377.)	3rd Most expensive	1st Cheapest	2nd Cheapest
503	13,343,886	16,099,741	6,272,144	10,496,970	356,426	5,400	(£ 62,265,622.)	(£ 55,966,267.)	(£ 62,143,477.)	3rd Most expensive	1st Cheapest	2nd Cheapest
504	13,866,562	16,799,099	6,517,822	10,950,659	371,909	5,635	(£ 64,866,034.)	(£ 58,292,793.)	(£ 64,738,578.)	3rd Most expensive	1st Cheapest	2nd Cheapest
505	14,389,239	17,498,457	6,763,500	11,404,348	387,392	5,870	(£ 67,466,445.)	(£ 60,619,320.)	(£ 67,333,679.)	3rd Most expensive	1st Cheapest	2nd Cheapest
506	14,911,915	18,197,814	7,009,178	11,858,037	402,875	6,104	(£ 70,066,857.)	(£ 62,945,846.)	(£ 69,928,780.)	3rd Most expensive	1st Cheapest	2nd Cheapest
507	15,434,592	18,897,172	7,254,857	12,311,726	418,358	6,339	(£ 72,667,268.)	(£ 65,272,373.)	(£ 72,523,881.)	3rd Most expensive	1st Cheapest	2nd Cheapest
508	15,957,269	19,596,530	7,500,535	12,765,415	433,841	6,573	(£ 75,267,680.)	(£ 67,598,899.)	(£ 75,118,982.)	3rd Most expensive	1st Cheapest	2nd Cheapest
509	16,479,945	20,295,888	7,746,213	13,219,105	449,323	6,808	(£ 77,868,091.)	(£ 69,925,426.)	(£ 77,714,083.)	3rd Most expensive	1st Cheapest	2nd Cheapest
510	17,002,622	20,995,246	7,991,891	13,672,794	464,806	7,043	(£ 80,468,503.)	(£ 72,251,952.)	(£ 80,309,184.)	3rd Most expensive	1st Cheapest	2nd Cheapest
511	2,718,177	1,828,510	1,277,648	1,268,568	40,481	613	(£ 8,566,721.)	(£ 7,850,607.)	(£ 9,285,632.)	2nd Cheapest	1st Cheapest	3rd Most expensive
512	4,047,917	3,618,236	1,902,678	2,461,538	80,103	1,214	(£ 14,420,860.)	(£ 12,988,632.)	(£ 15,858,680.)	2nd Cheapest	1st Cheapest	3rd Most expensive
513	5,408,510	5,419,289	2,542,209	3,660,798	119,976	1,818	(£ 20,274,999.)	(£ 18,126,656.)	(£ 22,551,394.)	2nd Cheapest	1st Cheapest	3rd Most expensive
514	6,755,881	7,215,487	3,175,526	4,857,362	159,741	2,420	(£ 26,214,613.)	(£ 23,264,680.)	(£ 29,192,823.)	2nd Cheapest	1st Cheapest	3rd Most expensive
515	8,125,288	9,019,777	3,819,201	6,058,420	199,686	3,026	(£ 32,196,964.)	(£ 28,488,180.)	(£ 35,919,727.)	2nd Cheapest	1st Cheapest	3rd Most expensive
516	9,481,474	10,819,212	4,456,660	7,256,781	239,523	3,629	(£ 38,128,030.)	(£ 33,745,870.)	(£ 42,595,346.)	2nd Cheapest	1st Cheapest	3rd Most expensive
517	10,864,986	12,628,680	5,106,964	8,460,714	279,582	4,236	(£ 44,165,086.)	(£ 39,052,565.)	(£ 49,376,954.)	2nd Cheapest	1st Cheapest	3rd Most expensive
518	12,228,223	14,430,704	5,747,739	9,660,514	319,476	4,841	(£ 50,123,504.)	(£ 44,280,624.)	(£ 56,079,926.)	2nd Cheapest	1st Cheapest	3rd Most expensive
519	13,591,460	16,232,728	6,388,513	10,860,313	359,371	5,445	(£ 56,081,923.)	(£ 49,508,682.)	(£ 62,782,897.)	2nd Cheapest	1st Cheapest	3rd Most expensive
520	14,954,698	18,034,752	7,029,288	12,060,112	399,265	6,049	(£ 62,040,341.)	(£ 54,736,740.)	(£ 69,485,868.)	2nd Cheapest	1st Cheapest	3rd Most expensive
521	16,317,935	19,836,776	7,670,062	13,259,912	439,159	6,654	(£ 67,998,760.)	(£ 59,964,799.)	(£ 76,188,839.)	2nd Cheapest	1st Cheapest	3rd Most expensive
522	17,681,172	21,638,800	8,310,836	14,459,711	479,054	7,258	(£ 73,957,178.)	(£ 65,192,857.)	(£ 82,891,810.)	2nd Cheapest	1st Cheapest	3rd Most expensive
523	19,044,410	23,440,824	8,951,611	15,659,510	518,948	7,863	(£ 79,915,596.)	(£ 70,420,915.)	(£ 89,594,781.)	2nd Cheapest	1st Cheapest	3rd Most expensive
524	20,407,647	25,242,848	9,592,385	16,859,310	558,842	8,467	(£ 85,874,015.)	(£ 75,648,974.)	(£ 96,297,752.)	2nd Cheapest	1st Cheapest	3rd Most expensive
525	21,770,885	27,044,873	10,233,160	18,059,109	598,737	9,072	(£ 91,832,433.)	(£ 80,877,032.)	(£ 103,000,723.)	2nd Cheapest	1st Cheapest	3rd Most expensive
526	3,228,292	2,523,256	1,517,422	1,719,696	55,861	846	(£ 11,128,028.)	(£ 10,143,371.)	(£ 11,832,012.)	2nd Cheapest	1st Cheapest	3rd Most expensive
527	5,094,593	5,017,437	2,394,656	3,369,186	111,079	1,683	(£ 19,543,473.)	(£ 17,574,159.)	(£ 21,054,010.)	2nd Cheapest	1st Cheapest	3rd Most expensive
528	6,958,690	7,510,809	3,270,854	5,018,226	166,279	2,519	(£ 28,049,736.)	(£ 25,004,947.)	(£ 30,267,462.)	2nd Cheapest	1st Cheapest	3rd Most expensive
529	8,849,231	10,013,890	4,159,482	6,672,658	221,694	3,359	(£ 36,626,516.)	(£ 32,538,306.)	(£ 39,583,484.)	2nd Cheapest	1st Cheapest	3rd Most expensive
530	10,751,894	12,521,421	5,053,807	8,329,561	277,207	4,200	(£ 45,250,307.)	(£ 40,229,081.)	(£ 48,946,517.)	2nd Cheapest	1st Cheapest	3rd Most expensive
531	12,637,808	15,022,803	5,940,260	9,983,050	332,584	5,039	(£ 53,809,137.)	(£ 47,783,666.)	(£ 58,244,589.)	2nd Cheapest	1st Cheapest	3rd Most expensive
532	14,523,722	17,524,184	6,826,712	11,636,538	387,962	5,878	(£ 62,367,967.)	(£ 55,338,251.)	(£ 67,542,661.)	2nd Cheapest	1st Cheapest	3rd Most expensive
533	16,409,636	20,025,566	7,713,165	13,290,027	443,339	6,717	(£ 70,926,797.)	(£ 62,892,836.)	(£ 76,840,733.)	2nd Cheapest	1st Cheapest	3rd Most expensive
534	18,295,550	22,526,948	8,599,618	14,943,515	498,716	7,556	(£ 79,485,627.)	(£ 70,447,421.)	(£ 86,138,805.)	2nd Cheapest	1st Cheapest	3rd Most expensive
535	20,181,464	25,028,330	9,486,070	16,597,004	554,093	8,395	(£ 88,044,456.)	(£ 78,002,005.)	(£ 95,436,876.)	2nd Cheapest	1st Cheapest	3rd Most expensive
536	22,067,378	27,529,712	10,372,523	18,250,492	609,470	9,234	(£ 96,603,286.)	(£ 85,556,590.)	(£ 104,734,948.)	2nd Cheapest	1st Cheapest	3rd Most expensive
537	23,953,292	30,031,094	11,258,976	19,903,981	664,848	10,073	(£ 105,162,116.)	(£ 93,111,175.)	(£ 114,033,020.)	2nd Cheapest	1st Cheapest	3rd Most expensive
538	25,839,206	32,532,476	12,145,428	21,557,469	720,225	10,912	(£ 113,720,946.)	(£ 100,665,760.)	(£ 123,331,092.)	2nd Cheapest	1st Cheapest	3rd Most expensive
539	27,725,120	35,033,858	13,031,881	23,210,958	775,602	11,752	(£ 122,279,776.)	(£ 108,220,345.)	(£ 132,629,164.)	2nd Cheapest	1st Cheapest	3rd Most expensive
540	29,611,033	37,535,240	13,918,334	24,864,446	830,979	12,591	(£ 130,838,606.)	(£ 115,774,930.)	(£ 141,927,236.)	2nd Cheapest	1st Cheapest	3rd Most expensive

X. APPENDICES

APPENDIX I WLCC NPV (DISCOUNTED) WORKSHEET – BHS SAMPLE DATA

Fully Automatic BHS (Year in service)

Item	Name	(£)	Year in service	Life	Sub Totals £
1	**Capital cost**	CAPEX (COST)			
2	Baggage Building CAPEX	(£ 34,193,487.)	2013	15	
3	Baggage System CAPEX	(£ 32,744,905.)	2013	15	
4	Construction capitalized "On-cost assets" CAPEX	(£ 15,391,375.)	2013	15	
5					
6	**Residual asset values (Year 15)**	Resideual assest value (Year 15)			
7	Baggage Building CAPEX	£ 0.			
8	Baggage System CAPEX	£ 0.			
9	Construction capitalized "On-cost assets" CAPEX	£ 0.			
10				CASH OUT	$CAPEX_{Total\ Net}$
11	**Operating cost**	OPEX / Annum (Year 1) (COST)			
12	Baggage OPEX (including inflation)	(£ 19,157,910.)			
13	Building OPEX (including inflation)	(£ 722,499.)			
14	**Sub total: $OPEX_{Total\ Net}$**			CASH OUT	$OPEX_{Total\ Net}$
15	**Income from Bag Charge**	BAG CHARGE / Annum (Year 1) INCOME			
16	**Bag charge income per annum: Bags / Hour x 18hours/day x 365 days/year x 50% system utilisation x OPEX Factor x Bag charge + inflation**	£ 19,187,685.		CASH IN	$BAG\ CHARGE_{Total\ Net}$
					Net Cash Flow
17					DCF Rate in YEAR "n"
18	**NPV: ($CAPEX_{TOTAL\ NET}$ + $OPEX_{TOTAL\ NET}$ + $BAGCHARGE_{TOTAL\ NET}$) x DCF**				Present Value
					Cummulative NPV

Item	2012	2013	2014	2015	2016	2017	2018	2019
Year "n"	0	1	2	3	4	5	6	7
2	£ 0.	(£ 34,193,487.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
3	£ 0.	(£ 32,744,905.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
4	£ 0.	(£ 15,391,375.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
10	£ 0.	(£ 82,329,767.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
12	£ 0.	(£ 19,157,910.)	(£ 19,732,647.)	(£ 20,324,627.)	(£ 20,934,366.)	(£ 21,562,397.)	(£ 22,209,268.)	(£ 22,875,546.)
13	£ 0.	(£ 722,499.)	(£ 744,174.)	(£ 766,499.)	(£ 789,494.)	(£ 813,179.)	(£ 837,574.)	(£ 862,702.)
14	£ 0.	(£ 19,880,409.)	(£ 20,476,821.)	(£ 21,091,126.)	(£ 21,723,860.)	(£ 22,375,575.)	(£ 23,046,843.)	(£ 23,738,248.)
16	£ 0.	£ 19,187,685.	£ 19,763,316.	£ 20,356,215.	£ 20,966,901.	£ 21,595,909.	£ 22,243,786.	£ 22,911,099.
Net Cash Flow	£ 0.	(£ 83,022,491.)	(£ 713,506.)	(£ 734,911.)	(£ 756,958.)	(£ 779,667.)	(£ 803,057.)	(£ 827,149.)
17	1.000	0.927	0.859	0.797	0.738	0.685	0.635	0.588
18	£ 0.	(£ 76,961,753.)	(£ 613,135.)	(£ 585,426.)	(£ 558,970.)	(£ 533,710.)	(£ 509,591.)	(£ 486,562.)
Cummulative NPV	£ 0.	(£ 76,961,753.)	(£ 77,574,888.)	(£ 78,160,314.)	(£ 78,719,284.)	(£ 79,252,994.)	(£ 79,762,584.)	(£ 80,249,146.)

Item	2020	2021	2022	2023	2024	2025	2026	2027
Year "n"	8	9	10	11	12	13	14	15
2	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
3	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
4	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
7								£ 0.
8								£ 0.
9								£ 0.
10	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
12	(£ 23,561,813.)	(£ 24,268,667.)	(£ 24,996,727.)	(£ 25,746,629.)	(£ 26,519,028.)	(£ 27,314,599.)	(£ 28,134,037.)	(£ 28,978,058.)
13	(£ 888,583.)	(£ 915,240.)	(£ 942,697.)	(£ 970,978.)	(£ 1,000,108.)	(£ 1,030,111.)	(£ 1,061,014.)	(£ 1,092,844.)
14	(£ 24,450,395.)	(£ 25,183,907.)	(£ 25,939,425.)	(£ 26,717,607.)	(£ 27,519,135.)	(£ 28,344,710.)	(£ 29,195,051.)	(£ 30,070,902.)
16	£ 23,598,432.	£ 24,306,385.	£ 25,035,577.	£ 25,786,644.	£ 26,560,243.	£ 27,357,051.	£ 28,177,762.	£ 29,023,095.
Net Cash Flow	(£ 851,963.)	(£ 877,522.)	(£ 903,848.)	(£ 930,963.)	(£ 958,892.)	(£ 987,659.)	(£ 1,017,289.)	(£ 1,047,807.)
17	0.545	0.505	0.469	0.434	0.403	0.373	0.346	0.321
18	(£ 464,573.)	(£ 443,579.)	(£ 423,533.)	(£ 404,393.)	(£ 386,118.)	(£ 368,669.)	(£ 352,008.)	(£ 336,101.)
Cummulative NPV	(£ 80,713,720.)	(£ 81,157,298.)	(£ 81,580,831.)	(£ 81,985,224.)	(£ 82,371,342.)	(£ 82,740,011.)	(£ 83,092,019.)	(£ 83,428,120.)

19 **Life end (15 years) WLCC (Discounted to Present Day Value)** (£ 83,428,120.)

Semi Automatic BHS (Year in service)

Item	Name	(£)	Year in service	Life	Sub Totals £
1	**Capital cost**	CAPEX (COST)			
2	Baggage Building CAPEX	(£ 33,278,283.)	2013	15	
3	Baggage System CAPEX	(£ 30,115,749.)	2013	15	
4	Construction capitalized "On-cost assets" CAPEX	(£ 14,155,569.)	2013	15	
5					
6	**Residual asset values (Year 15)**	Resideual assest value (Year 15)			
7	Baggage Building CAPEX	£ 0.			
8	Baggage System CAPEX	£ 0.			
9	Construction capitalized "On-cost assets" CAPEX	£ 0.			
10				CASH OUT	$CAPEX_{Total\ Net}$
11	**Operating cost**	OPEX / Annum (Year 1) (COST)			
12	Baggage OPEX (including inflation)	(£ 18,798,446.)			
13	Building OPEX (including inflation)	(£ 705,852.)			
14	**Sub total: $OPEX_{Total\ Net}$**			CASH OUT	$OPEX_{Total\ Net}$
15	**Income from Bag Charge**	BAG CHARGE / Annum (Year 1) INCOME			
16	**Bag charge income per annum: Bags / Hour x 18hours/day x 365 days/year x 50% system utilisation x OPEX Factor x Bag charge + inflation**	£ 19,187,685.		CASH IN	$BAG\ CHARGE_{Total\ Net}$
					Net Cash Flow
17					DCF Rate in YEAR "n"
18	**NPV: ($CAPEX_{TOTAL\ NET}$ + $OPEX_{TOTAL\ NET}$ + $BAGCHARGE_{TOTAL\ NET}$) x DCF**				Present Value
					Cummulative NPV

Item	2012	2013	2014	2015	2016	2017	2018	2019
2	£ 0.	(£ 33,278,283.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
3	£ 0.	(£ 30,115,749.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
4	£ 0.	(£ 14,155,569.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
10	£ 0.	(£ 77,549,601.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
12	£ 0.	(£ 18,798,446.)	(£ 19,362,399.)	(£ 19,943,271.)	(£ 20,541,569.)	(£ 21,157,816.)	(£ 21,792,551.)	(£ 22,446,327.)
13	£ 0.	(£ 705,852.)	(£ 727,027.)	(£ 748,838.)	(£ 771,303.)	(£ 794,442.)	(£ 818,276.)	(£ 842,824.)
14	£ 0.	(£ 19,504,297.)	(£ 20,089,426.)	(£ 20,692,109.)	(£ 21,312,872.)	(£ 21,952,259.)	(£ 22,610,826.)	(£ 23,289,151.)
16	£ 0.	£ 19,187,685.	£ 19,763,316.	£ 20,356,215.	£ 20,966,901.	£ 21,595,909.	£ 22,243,786.	£ 22,911,099.
Net Cash Flow	£ 0.	(£ 77,866,214.)	(£ 326,111.)	(£ 335,894.)	(£ 345,971.)	(£ 356,350.)	(£ 367,041.)	(£ 378,052.)
17	1.000	0.927	0.859	0.797	0.738	0.685	0.635	0.588
18	£ 0.	(£ 72,181,890.)	(£ 280,236.)	(£ 267,572.)	(£ 255,480.)	(£ 243,934.)	(£ 232,911.)	(£ 222,385.)
Cummulative NPV	£ 0.	(£ 72,181,890.)	(£ 72,462,126.)	(£ 72,729,697.)	(£ 72,985,177.)	(£ 73,229,111.)	(£ 73,462,022.)	(£ 73,684,407.)

Item	2020	2021	2022	2023	2024	2025	2026	2027
2	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
3	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
4	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
7								£ 0.
8								£ 0.
9								£ 0.
10	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
12	(£ 23,119,717.)	(£ 23,813,309.)	(£ 24,527,708.)	(£ 25,263,539.)	(£ 26,021,445.)	(£ 26,802,089.)	(£ 27,606,151.)	(£ 28,434,336.)
13	(£ 868,109.)	(£ 894,152.)	(£ 920,976.)	(£ 948,606.)	(£ 977,064.)	(£ 1,006,376.)	(£ 1,036,567.)	(£ 1,067,664.)
14	(£ 23,987,826.)	(£ 24,707,460.)	(£ 25,448,684.)	(£ 26,212,145.)	(£ 26,998,509.)	(£ 27,808,464.)	(£ 28,642,718.)	(£ 29,502,000.)
16	£ 23,598,432.	£ 24,306,385.	£ 25,035,577.	£ 25,786,644.	£ 26,560,243.	£ 27,357,051.	£ 28,177,762.	£ 29,023,095.
Net Cash Flow	(£ 389,393.)	(£ 401,075.)	(£ 413,107.)	(£ 425,501.)	(£ 438,266.)	(£ 451,414.)	(£ 464,956.)	(£ 478,905.)
17	0.545	0.505	0.469	0.434	0.403	0.373	0.346	0.321
18	(£ 212,335.)	(£ 202,740.)	(£ 193,577.)	(£ 184,829.)	(£ 176,477.)	(£ 168,502.)	(£ 160,887.)	(£ 153,616.)
Cummulative NPV	(£ 73,896,742.)	(£ 74,099,481.)	(£ 74,293,059.)	(£ 74,477,888.)	(£ 74,654,365.)	(£ 74,822,867.)	(£ 74,983,754.)	(£ 75,137,370.)

19 **Life end (15 years) WLCC (Discounted to Present Day Value)** (£ 75,137,370.)

Manual BHS (Year in service)

Item	Name	(£)	Year in service	Life	Sub Totals £
1	**Capital cost**	CAPEX (COST)			
2	Baggage Building CAPEX	(£ 37,317,574.)	2013	15	
3	Baggage System CAPEX	(£ 29,611,033.)	2013	15	
4	Construction capitalized "On-cost assets" CAPEX	(£ 13,918,334.)	2013	15	
5					
6	**Residual asset values (Year 15)**	Resideual assest value (Year 15)			
7	Baggage Building CAPEX	£ 0.			
8	Baggage System CAPEX	£ 0.			
9	Construction capitalized "On-cost assets" CAPEX	£ 0.			
10				CASH OUT	$CAPEX_{Total\ Net}$
11	**Operating cost**	OPEX / Annum (Year 1) (COST)			
12	Baggage OPEX (including inflation)	(£ 19,608,765.)			
13	Building OPEX (including inflation)	(£ 826,160.)			
14	**Sub total: $OPEX_{Total\ Net}$**			CASH OUT	$OPEX_{Total\ Net}$
15	**Income from Bag Charge**	BAG CHARGE / Annum (Year 1) INCOME			
16	**Bag charge income per annum: Bags / Hour x 18hours/day x 365 days/year x 50% system utilisation x OPEX Factor x Bag charge + inflation**	£ 19,187,685.		CASH IN	$BAG\ CHARGE_{Total\ Net}$
					Net Cash Flow
17					DCF Rate in YEAR "n"
18	**NPV: ($CAPEX_{TOTAL\ NET}$ + $OPEX_{TOTAL\ NET}$ + $BAGCHARGE_{TOTAL\ NET}$) x DCF**				Present Value
					Cummulative NPV

Item	2012	2013	2014	2015	2016	2017	2018	2019
2	£ 0.	(£ 37,317,574.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
3	£ 0.	(£ 29,611,033.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
4	£ 0.	(£ 13,918,334.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
10	£ 0.	(£ 80,846,941.)	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
12	£ 0.	(£ 19,608,765.)	(£ 20,197,028.)	(£ 20,802,939.)	(£ 21,427,027.)	(£ 22,069,838.)	(£ 22,731,933.)	(£ 23,413,891.)
13	£ 0.	(£ 826,160.)	(£ 850,945.)	(£ 876,474.)	(£ 902,768.)	(£ 929,851.)	(£ 957,746.)	(£ 986,479.)
14	£ 0.	(£ 20,434,926.)	(£ 21,047,974.)	(£ 21,679,413.)	(£ 22,329,795.)	(£ 22,999,689.)	(£ 23,689,680.)	(£ 24,400,370.)
16	£ 0.	£ 19,187,685.	£ 19,763,316.	£ 20,356,215.	£ 20,966,901.	£ 21,595,909.	£ 22,243,786.	£ 22,911,099.
Net Cash Flow	£ 0.	(£ 82,094,182.)	(£ 1,284,658.)	(£ 1,323,198.)	(£ 1,362,894.)	(£ 1,403,780.)	(£ 1,445,894.)	(£ 1,489,271.)
17	1.000	0.927	0.859	0.797	0.738	0.685	0.635	0.588
18	£ 0.	(£ 76,101,212.)	(£ 1,103,941.)	(£ 1,054,053.)	(£ 1,006,419.)	(£ 960,938.)	(£ 917,512.)	(£ 876,048.)
Cummulative NPV	£ 0.	(£ 76,101,212.)	(£ 77,205,153.)	(£ 78,259,205.)	(£ 79,265,624.)	(£ 80,226,562.)	(£ 81,144,073.)	(£ 82,020,121.)

Item	2020	2021	2022	2023	2024	2025	2026	2027
2	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
3	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
4	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
7								£ 0.
8								£ 0.
9								£ 0.
10	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.	£ 0.
12	(£ 24,116,308.)	(£ 24,839,797.)	(£ 25,584,991.)	(£ 26,352,541.)	(£ 27,143,117.)	(£ 27,957,411.)	(£ 28,796,133.)	(£ 29,660,017.)
13	(£ 1,016,073.)	(£ 1,046,555.)	(£ 1,077,952.)	(£ 1,110,290.)	(£ 1,143,599.)	(£ 1,177,907.)	(£ 1,213,244.)	(£ 1,249,642.)
14	(£ 25,132,381.)	(£ 25,886,353.)	(£ 26,662,943.)	(£ 27,462,831.)	(£ 28,286,716.)	(£ 29,135,318.)	(£ 30,009,377.)	(£ 30,909,659.)
16	£ 23,598,432.	£ 24,306,385.	£ 25,035,577.	£ 25,786,644.	£ 26,560,243.	£ 27,357,051.	£ 28,177,762.	£ 29,023,095.
Net Cash Flow	(£ 1,533,949.)	(£ 1,579,967.)	(£ 1,627,366.)	(£ 1,676,187.)	(£ 1,726,473.)	(£ 1,778,267.)	(£ 1,831,615.)	(£ 1,886,564.)
17	0.545	0.505	0.469	0.434	0.403	0.373	0.346	0.321
18	(£ 836,459.)	(£ 798,658.)	(£ 762,566.)	(£ 728,104.)	(£ 695,200.)	(£ 663,784.)	(£ 633,786.)	(£ 605,145.)
Cummulative NPV	(£ 82,856,580.)	(£ 83,655,238.)	(£ 84,417,804.)	(£ 85,145,908.)	(£ 85,841,108.)	(£ 86,504,892.)	(£ 87,138,678.)	(£ 87,743,823.)

19 **Life end (15 years) WLCC (Discounted to Present Day Value)** (£ 87,743,823.)

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APPENDIX J SUBROUTINE MACRO: EXPERIMENTATION DATA INPUT AND DATA RECORDING

```
'Macro
'
' Keyboard Shortcut: Ctrl+n
'
    Range("F16:T16").Select
    Selection.Copy
    Range("F14").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
    Range("D12:AO12").Select
    Application.CutCopyMode = False
    Selection.Copy
    ActiveWindow.SmallScroll ToRight:=-19
    Range("D16").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
'
Comment: Macro Repeated F16:T16 to F75:T75
'
    Range("F75:T75").Select
    Selection.Copy
    Range("F14").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
    Range("D12:AO12").Select
    Application.CutCopyMode = False
    Selection.Copy
    ActiveWindow.SmallScroll ToRight:=-19
    Range("D75").Select
    Selection.PasteSpecial Paste:=xlPasteValues, Operation:=xlNone, SkipBlanks _
        :=False, Transpose:=False
'
End Sub
```

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APPENDIX K IATA CAPEX / OPEX ADJUSTMENT FACTORS

SOURCE: IATA AIRPORT DEVELOPMENT DEVFERENCE MANUAL 9TH EDITION

Continent	Country	Factor (UK = 100)
Africa	Algeria	55
Africa	Cameroon	67
Africa	Chad	66
Africa	Cote d'Ivoire	71
Africa	Gabon	67
Africa	Gambia	74
Africa	Ghana	80
Africa	Nigeria	65
Africa	Senegal	67
Africa	South Africa	26
Africa	Zambia	45
Asia	Brunei	40
Asia	China	56
Asia	Hong Kong	72
Asia	India	19
Asia	Indonesia	47
Asia	Japan	110
Asia	Malaysia	29
Asia	Philippines	37
Asia	Singapore	59
Asia	South Korea	66
Asia	Sri Lanka	21
Asia	Taiwan	62
Asia	Thailand	43
Asia	Vietnam	47

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APPENDIX K IATA CAPEX / OPEX ADJUSTMENT FACTORS CONTINUED

SOURCE: IATA AIRPORT DEVELOPMENT DEVFERENCE MANUAL 9TH EDITION

Continent	Country	Factor (UK = 100)
C America	Costa Rica	59
C America	Mexico	70
Caribbean	Bahamas	84
Caribbean	Jamaica	65
Caribbean	Puerto Rico	78
Europe	Austria	80
Europe	Belgium	84
Europe	Cyprus	46
Europe	Czech Rep	51
Europe	Finland	80
Europe	France	80
Europe	Germany	72
Europe	Greece	51
Europe	Ireland	96
Europe	Italy	73
Europe	Netherlands	79
Europe	Poland	56
Europe	Portugal	52
Europe	Romania	30
Europe	Slovak Rep	33
Europe	Spain	60
Europe	Switzerland	89
Middle East	Bahrain	68
Middle East	Egypt	57
Middle East	Israel	45
Middle East	Jordan	60
Middle East	Kuwait	66
Middle East	Lebanon	66
Middle East	Oman	62
Middle East	Qatar	66
Middle East	Saudi Arabia	57

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APPENDIX K IATA CAPEX / OPEX ADJUSTMENT FACTORS CONTINUED

SOURCE: IATA AIRPORT DEVELOPMENT DEVFERENCE MANUAL 9TH EDITION

Continent	Country	Factor (UK = 100)
S America	Argentina	20
S America	Brazil	49
S America	Chile	43
S America	Colombia	57
S America	French Guiana	84
S America	Guyana	65
S America	Peru	53
S America	Venezuela	37

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APPENDIX L THESIS RESULTS TARGET AUDIENCE

MODEL	PRIMARY USERS					
INPUTS AND OUTPUTS	**AIRPORT AUTTHORITIES**	**AIRLINES**	**BHS SUPPLIERS**	**COST CONSULTANTS**	**REGULATORS**	**ARCHITECTS & CONSULTANTS**
DESIGN						
DEFINES BAGGAGE HANDLING SYSTEM COMPONENTS	•		•	•		•
DEFINES BAGGAGE HANDLING SYSTEM BUILDING SIZE / LEVELS / GRIDS	•		•	•		•
DEFINES MULTIPLE TECHNOLOGY OPTIONS	•	•	•	•		•
COSTS						
DEFINES BAGGAGE SYSTEM CAPITAL COSTS	•	•	•	•	•	
DEFINES BAGGAGE BUILDING CAPITAL COSTS	•	•	•	•	•	
DEFINES BAGGAGE SYSTEM OPERATING COSTS	•	•	•	•	•	
DEFINES BAGGAGE BUILDING OPERATING COSTS	•	•	•	•	•	
DEFINES PROJECT WHOLE LIFE CYCLE COSTS	•	•	•	•	•	
DEFINES COSTS PER BAG	•	•	•	•	•	
DEFINES PROJECT ON COSTS	•	•	•	•	•	
PEOPLE ISSUES						
DEFINES QUANTITY STAFF REQUIRED FOR CONVENTIONAL BHS	•	•	•			•
DEFINES QUANTITY STAFF REQUIRED FOR SEMI AUTOMATIC BHS	•	•	•			•
DEFINES QUANTITY STAFF REQUIRED FOR ROBOTIC FULLY AUTOMATIC BHS	•	•	•			•

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APPENDIX M EXAMPLE OF ASSEMBLED BHS COMPONENTS